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The first issue of				1888 cont'ined		175	different adv'ts.
1881 contained		28	different adv'ts.	1889	"	234	" "
1882	"	45	" "	1890	"	289	" "
1883	"	63	" "	1891	"	325	" "
1884	"	82	" "	1892	"	316	" "
1885	"	100	" "	1893	"	317	" "
1886	"	138	" "				
1887	"	154	" "				

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Of no issue of The Electrical World for years have fewer than 9,000 copies been printed and published, while for a long time no issue has consisted of less than 10,000 copies, and the number of copies actually printed and published has of late in many instances reached 11,500. Mr. Johnston holds himself personally responsible for the accuracy of these figures and for the statement that no other electrical journal in America, or in Europe, or in the world, regularly issues one-third as many copies.

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Special Notice.—*The Western office of The Electrical World, which has for several years been located at 465 The Rookery, Chicago, will hereafter be found at 936 Monadnock Block, where larger, more convenient and more cheerful quarters have been obtained in the new wing known as "Section C." This addition to the original building is really not yet entirely completed in its internal arrangements. For instance, the elevator which is to run in front of The Electrical World's office will not be in commission for several weeks, but in the meantime one of the other elevators, of which there are a dozen or so, can be taken to the ninth floor. It is to be hoped that the Chicago friends of The Electrical World and those visiting the World's Fair city will make a point of visiting the office, where they can always rely upon a cordial welcome.*

VOL. XXI. NEW YORK, JUNE 3, 1893. NO. 22

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Technical Education in Europe. WE begin in this issue a series of articles on technical education in Europe which, besides being of general interest, will afford data for comparison with our own admirable schools of technology. If a magnificent building with sumptuous embellishments were the criterion, the technical school of Berlin-Charlottenburg is vastly in advance of anything in America. As will be seen, the technical course at this school is practical in character, and the equipment of commercial apparatus is very complete: this, taken in connection with the statement of the professors that the object of the course is to educate electrical engineers rather than electricians, indicates a decidedly practical standard not usually thought of in connection with Continental schools.

Symbol for Current. MR. HOSPITALIER'S excellent suggestions regarding an international system of symbols, reprinted in the May number of the Transactions of the American Institute of Electrical Engineers, deserve the most careful consideration of the Delegates to the Congress. There is one suggestion, however, which English speaking people will not be likely to adopt, that is, the change from C to I as the symbol representing current. While we appreciate the fact that in adopting such an international system all different countries must yield some points for the common good, it will be hard, if at all possible, for Americans and English to give up their classic form of Ohm's law or their favorite C^2R and write I in place of C. In this connection we recommend the delegates and others who are interested to the suggestions contained in the Institute's report, namely, to represent capacity by K, moment of inertia by I, and thereby leave the symbol C to represent the current.

The Tesla Lecture. ELSEWHERE in this issue will be found the full text of the lecture delivered by Mr. Nikola Tesla before the Franklin Institute and, a little later, the National Electric Light Association at St. Louis, and for which the electrical public have been anxiously waiting ever since. The matter is in quite a different form from that in which it was laid before the public at that time, as those who were present at the St. Louis Convention will readily recognize. The conditions were such then that it was impossible to treat so important a subject in anything like a complete and satisfactory manner. The lecture in its present form is evidence of the careful work Mr. Tesla has bestowed upon it, and it measures, to a certain extent, the progress he has made in that most interesting line of research since his last public utterances. A strong spirit of hope and prophecy is characteristic of this investigator and he again expresses his confidence in the methods of the transmission of energy which he has so long advocated.

Interest in Congress Matters. THE French, whom we have to thank largely for our excellent, simple and uniform sysytem of electrical units, are taking considerable interest in the Congress work started by the American Institute of Electrical Engineers, and their discussions, which have been abstracted fully in our columns, will be read with interest. The less energetic but no less thorough Germans are about to discuss our American propositions, but the English, who generally take such interest in these matters, appear to have been very lax in their discussions, and, strange to say, the Americans have been still more so. Whether this is due to procrastination, lack of interest, or perhaps even a fear to present their views to the public through the press, is left to conjecture, but we sincerely hope that it is not due to the latter. This matter *does* concern electricians in general, and anybody who has views to express but is afraid to do so in the journals or at society meetings, ought not to feel entitled to have his views considered at the Congress. Any opinions which cannot stand the criticisms of the reading public, which includes all the most eminent electricians, ought certainly not be entitled to consideration at the Congress sessions. We trust that our esteemed delegates, as well as those from the other countries, will act in accordance with the views and wishes of electricians whose representatives they are, and not give undue value to eleventh-hour suggestions or withheld propositions, which have not stood and perhaps will not stand the criticisms of those who really take a live interest in the matter for the benefit of the electrical fraternity at large.

Congress Proposals. THE work done by the American Institute of Electrical Engineers in starting a discussion of the subjects to be brought before the Congress has met with universal approval and praise abroad. The suggestion to discuss the subjects prior to the meeting of the Congress, reserving merely the decision for the Congress, has been fully indorsed and approved abroad. That the Institute's work has already borne good fruit is seen from the discussions in the English and French journals, particularly in the latter. All these discussions have been abstracted very fully in our Digest, the present issue containing an important contribution from Mr. Hospitalier, whose earnest efforts to establish uniformity, and more especially to introduce an international system of symbols, are well known to those who have followed this important subject. We call especial attention to his proposition for establishing a uniform system of symbols in electrical literature, which will be the same in all languages and countries, and will become as common and universally understood as the signs and symbols in algebra and trigonometry. The inestimable value of such a system is self-evident, and it is hoped that all the delegates to the Congress will give this subject their most careful consideration. Even if they cannot agree on a complete system let them adopt as many of the symbols as possible. As journalists, we appreciate perhaps more than others the great value of a universal system of symbols which do not require a lengthy interpretation in each article and which are not different in articles written by different authors.

Steam Engine Economy. IN another column we print a careful abstract of the important and lengthy Institute paper of Prof. Carpenter on the variation of economy of the steam engine due to variation in load, to which we referred editorially last week. No subject in steam engineering has been in greater doubt than the one which is here so exhaustively treated, and very few have a greater practical interest, and this is particularly true as applied to engines running electrical machinery. Heretofore the question of the economy of different types of engines running under the greatly varying loads incident to electrical machinery has been one almost entirely subject to conjecture alone, and the many discussions and widely-varying conclusions have had little value from the lack of a firm basis in fact. The great experimental demonstrations of Isherwood, of over thirty years ago, that steam cannot be expanded economically more than five or six times in a simple engine, paved the way for multiple cylinder engines, but even at the present day it cannot be said that we know exactly why the wastes should be so largely reduced by the employment of two or more cylinders, the fact being experimentally rather than theorectically established. In the light of this we need not be surprised that the formulæ established by Prof. Carpenter are almost purely empirical, and that they must be applied with some care, due consideration being given to the type and construction of the engine. The tables accompanying the paper, however, give the constants of all the usual types, so that the formulæ with this aid can be applied to almost any case that comes up in practice. The deductions drawn in the paper are interesting—for example, the one that the increase in water consumption is small when the extreme variation in load is confined between the limits of 50 per cent. above or below the normal or most economical load. This paper, with that of Dr. Emery, lately read before the Institute, will make the current volume of the Transactions of the Institute of Electrical Engineers not only of unusual value to electrical engineers, but even more so to the steam engineering profession at large.

Another Jenks. WE print in another column a letter from Lieut. Spencer, an employé of the General Electric Company, in relation to an article we recently published descriptive of the electrical fountains at the World's Fair. As the letter contained reflections upon the writer of the article, we naturally referred it to him before publishing, but it nevertheless appeared last week in the columns of a contemporary, the presumtive beneficiary of the issue raised. We now publish all the correspondence, so that our readers may see that Lieut. Spencer was not denied the opportunity of being heard by THE ELECTRICAL WORLD, as his sending the letter so promptly to another journal would seem to imply. Aside from the merits of the case we cannot reserve our opinion that the precipitate action of Lieut. Spencer shows little regard for the most ordinary amenities and gives little evidence of sagacity in thus permitting himself to be used as a tool to further the commercial interests of a would-be rival of THE ELECTRICAL WORLD. This is not the first time the anomaly has been presented of the contemporary referred to persistently depreciating an employer in its columns, while at the same time assiduously courting, presumably for "scoop" purposes, intimate relations with employés, who are rewarded by being used as ammunition when it is foolishly thought that a point against a rival may thus be gained. As an instance of this same—obliquity—the criticism in our columns to which Lieut. Spencer has been opposed as a shield, was directed against an article of our contemporary signed by the senior editor, thus conveying the impression that it was written by him on the spot. The reply to the criticism, however, is signed by the initials of the junior editor, who is thus made to stand in the breach, all of which is no doubt regarded as a brilliant piece of strategy. As to the subject matter of the letter of Lieut. Spencer, it is fully and squarely met by Mr. Perry, who apparently leaves as little for Lieut. Spencer to say as Mr. Jenks had to say after his disastrous effort to teach THE ELECTRICAL WORLD electrical engineering. It should be needless to say that the standing of THE ELECTRICAL WORLD and the well-earned reputation for fairness which it bears, are assurances that the unusual measures adopted by Lieut. Spencer are not necessary to secure careful consideratiou of a complaint. The sentiments the Lieutenant expresses with regard to the conduct of employés of THE ELECTRICAL WORLD are so impertinent that it is only the good nature of a journal older than the General Electric Company and generally considered as having reached the years of discretion, and therefore one that ought to set a good example, that prevents our sending Lieut. Spencer a telegram similar to the one sent to President Cleveland by the Governor of Oregon,

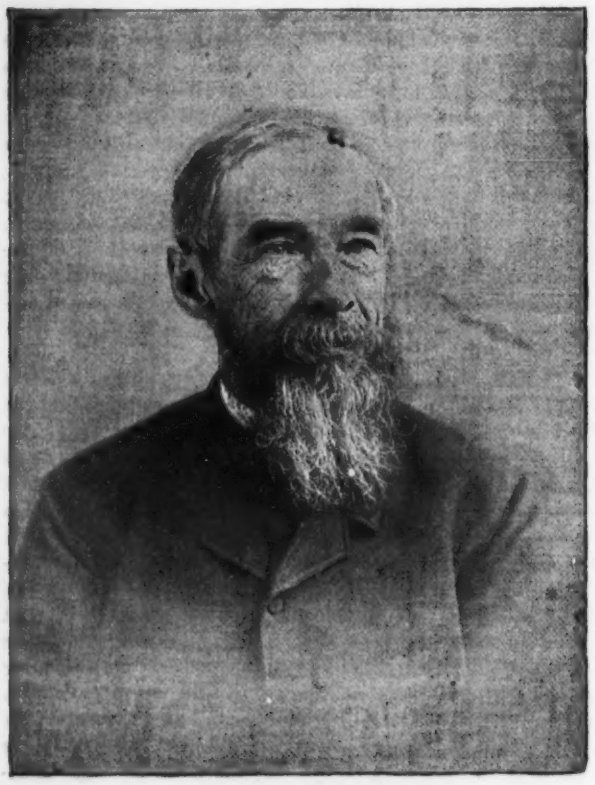
Electrical World Portraits—XXXVI.

MOSES G. FARMER.

The death of Moses G. Farmer, which occurred on Thursday, May 25, at 384 North State street, Chicago, has removed one of the earliest pioneers in the field of electricity. For more than half a century he was prominently identified with the various applications of electricity to industrial purposes, and a number of important inventions have been the result of his labors.

Moses Gerrish Farmer was born Feb. 9, 1820, at Boscawen, N. H. In 1844 he graduated from Dartmouth College. Two years later he had invented an electromagnetic engine, which with a miniature railroad he exhibited in connection with a lecture on electromagnetism. He showed at the same time how the electric current could be used for torpedoes and submarine blasting. He was appointed to open a telegraph office by the New York & Boston Magnetic Telegraph Association at South Framingham, Mass., and to superintend repairs between Boston, Worcester and Springfield. This gave him an opportunity to experiment on telegraphing by means of outside currents, and he contrived and constructed models of apparatus for fire alarms, bells, etc. He soon removed to Salem, Mass., to occupy a similar position, and continued his experimental work. In 1851 he became connected with Dr. W. F. Channing, of Boston, and they perfected a system of fire alarms under an appropriation of $10,000 by the Boston city government for this purpose. This resulted in Mr. Farmer's appointment as superintendent of construction of the Boston fire alarm telegraph, which was the first of the systems now in such general use throughout the country. In 1852 Mr. Farmer devised two or more closed circuit repeaters, and commenced the construction of apparatus for the simultaneous transmission of four messages on one wire, which was patented in 1853.

Mr. Farmer had now entered upon the wide field of ex-



MOSES G. FARMER.

perimental work and became interested in a great variety of subjects, such as dial telegraphs, duplex and multiple transmission, the manufacture of rubber insulators, etc. In 1856 he perfected the double transmission with reversed currents and constant resistance, and worked the system between Worcester and Boston, when two messages were sent simultaneously in opposite directions. This process was patented in 1858, and a second patent was secured a year later. At this period he constructed a duplex printing telegraph driven by an electromagnetic motor. In 1859 he invented an automatic regulator for controlling the distribution of electricity to electric lamps and began his investigation of the general subject of light by electricity. His own house in Salem was lighted by electricity in 1859, and is said to have been the first so illuminated. During 1865 and 1866 Mr. Farmer, in conjunction with G. F. Milliken, the manager of the Boston office of the Western Union Telegraph Company, invented what is known as compound wire, the core being of iron or steel with a copper cover. This led to the formation of the American Compound Wire Company, in 1868. About the same time he made another effort to introduce the duplex telegraph, which he successfully demonstrated on a circuit of 300 miles in Ohio. But there seems to have been no demand for this method at that time, and consequently the results were not successful. He also made some very successful experiments in the construction of permanent magnets. Later on he made many important improvements in dynamo-electric machines, one form of which is the well known Wallace-Farmer machine, another form being still used for torpedo work in the navy. In 1872 he accepted the position of electrician at the U. S. N. station at Newport, and discharged the duties of it till 1881, when he was compelled by ill health to retire. He still continued his investigations, however, and was always accounted among the foremost electrical experts of the day. He was a member of many scientific institutions.

"Lieut. E. Jenks Spencer."

Lightning is not usually supposed to strike twice in the same spot. Two different employees of the General Electric Company—we had almost said three—seem, however, with almost extraordinary lack of forethought and judgment, to have allowed themselves apparently to be made cats'-paws of by a shrewd electrical journal in its efforts to belittle and cast discredit upon The Electrical World.

The case of Mr. Jenks, who a few months ago made a laughing-stock of himself before the entire electrical fraternity, not only of America, but of Europe, owing to the precipitate and not at all courteous manner in which he sent to this other electrical journal a letter mistakenly criticising the accuracy of some technical statement made in The Electrical World, should have been a warning to others in a similar case to remember Davy Crockett's advice to "be sure you're right" before going ahead.

The Electrical World on that occasion would, if it could, have spared Mr. Jenks, who is not half a bad fellow at heart, the mortification of having his ignorance of electrical matters so unmistakably emphasized to the world. It also did its best, as the following correspondence will show, to prevent his latest disciple, Lieut. Spencer, from committing a similar error of judgment:

As, however, the valiant representative of the General Electric Company at the World's Fair chose to send for publication to the other paper referred to a letter addressed to The Electrical World, without waiting to see whether we were willing to print the letter, we feel that it is but fair to us that the entire correspondence should be given for the information of any it may concern.

The first intimation that Lieut. Spencer, or any one else outside of "The Electrical Engineer," had any fault to find with the article on the electrical fountains published in The Electrical World of May 13, was the receiption May 20, of the following letter:

The Electrical World:

GENTLEMEN—In your issue of May 13 you have seen fit to publish an account of electrical fountains at the World's Fair as constructed and operated by the General Electric Company, from the designs of Mr. Luther Stieringer:

In my capacity of representative of the General Electric Company, in the execution of this work, I wish to say that the article in question may be misleading in so far as you state that the fountains are not constructed in accordance with the plans published in "Electrical Engineer" of May 3. These plans are photographic reproductions of the original tracings, blueprints of which formed part of the contract executed between the General Electric Company and the World's Columbian Exposition. As a strict conformity with these plans is called for by the contract it may be inferred from your statement that our contract obligations have not been fulfilled. This inference would be unjust, inasmuch as there has been no deviation whatsoever from these plans. I trust that this statement will be published.

I wish also to call your attention to certain detailed electrical and other data in the same article. However, correct or incorrect, it has been secured from improper, irresponsible persons, without the approval or sanction of any one in authority. This is a matter of far more gravity than the mistaken statement just referred to.

Information asked from me has always been cheerfully furnished, except where business interests prevented. In one recent instance, upon your request for certain diagrams, rather than deny you the same on my own responsibility, I telegraphed East for advice. I then informed you that it was considered inadvisable to publish same at that time. Much to my surprise, such information as your representative could get—whether by permission of irresponsible parties or not it matters not—was published the following week.

Data for this fountain article has been obtained by methods of stealth and misrepresentation which I feel sure your able and influential journal cannot approve. Very truly yours, E. J. SPENCER.

The same day, May 20, the letter was referred to the editorial representative of The Electrical World at the World's Fair, and this letter was mailed to Lieut. Spencer:

Lieut. E. J. Spencer:

Dear Sir—Your favor May 16 duly to hand and will be referred to our editorial correspondent at the World's Fair.

Mr. Perry has a good reputation for accuracy, and he told me that he obtained most of the information regarding the fountains by making actual measurements. It was when he compared the reproductions of the original drawings that he claims to have found a difference.

Nowadays a journal likes to be also to some extent a newspaper, and not a historical publication. We found some difficulty, however, in getting information regarding the electrical fountains, because Mr. Stieringer had promised the information to other journals and did not wish to give it to us at the time we wanted it.

The "Electrical Engineer" felt a little put out because we illustrated and described the fountains before it had an opportunity to do so, and, as Mr. Perry thought, unnecessarily went out of its way to suggest that it was very reprehensible on the part of The Electrical World to print the article at all, and that it was full of inaccuracies.

When, later, the "Engineer" published an article on the subject Mr. Perry thought he had discovered quite a number of glaring errors in it, and, being human, he felt inclined, under all the circumstances, to point them out.

I am very sure that Mr. Perry did not wish to be unjust either to the "Electrical Engineer" or to you or Mr. Stieringer or anybody else. I certainly think you are entirely mistaken in saying that he obtained any information "by stealth and misrepresentation."

A journal like The Electrical World, which, at considerable expense, sends able representatives to the World's Fair, ought to be encouraged in securing as full and complete reports as it can of the exhibits, instead of being found fault with if it does not go about securing the information in a particular way. It does not desire to print matter that there is any impropriety in publishing, and no journal is more conscientious in respecting confidences when it feels that it is being treated frankly and at least as well as other journals.

As above stated, we are referring your letter to Mr. Perry, who will doubtless call upon you and satisfy you that you are laboring under some misapprehension in regard to the matter.

Trusting that the exhibit of the General Electric Company may be the success it deserves to be, I remain, sincerely yours, W. J. JOHNSTON.

On May 22, at 4:30 in the afternoon, a telegram was received from Mr. Perry, saying that he thought it best that Lieut. Spencer's letter should be published in full. As the issue of the paper that went to press that day was then "made up," the letter could not be published in it, and the following letter of explanation was sent to Lieut. Spencer:

NEW YORK, May 23, 1893.

Lieut. E. J. Spencer:

Dear Sir—In my letter of Saturday, replying to your favor of May 16, I said I would refer the matter to Mr. Perry in Chicago. I did so, and about half-past four yesterday afternoon we received a telegram from him saying that he thought we ought to publish your letter in full. Unfortunately, however, the telegram reached us too late to get the letter in the issue which went to press yesterday.

While I do not know anything as to the accuracy or inaccuracy of the statements made by Mr. Perry in this particular instance, The Electrical World is broad enough to promptly publish a correction when necessary. I therefore regret the delay.

I cannot but think, though, that Mr. Perry was conscientious in making the statement he did, and if they were not correct in any particular, that this was entirely unintentional on Mr. Perry's part.

I may be in Chicago next week, and if so will give myself the pleasure of calling upon you.

Sincerely yours, W. J. JOHNSTON.

Judge of the surprise in the office of The Electrical World when it was found that Lieut. Spencer's letter addressed to us was published in the "Electrical Engineer," which reached us May 24.

On May 25 the following unique epistle from Lieut. Spencer was received:

CHICAGO, May 22, 1893.

Mr. W. J. Johnston, Times Building, New York City:

Dear Sir—I have your favor of the 20th inst., and have read the same with great care and attention. Your representative is denied nothing that he asks for in the shape of information, except it be a matter of business policy. My statement to you is based upon the fact that he entered our fountains, took sketches of the same and from the lamps, representing to one of my men that he had authority to do what he was doing. I trust that this course of procedure will never again be adopted by any one connected with your journal.

Very truly yours,

E. J. SPENCER.

Mr. Perry's Compliments to Lieut. Spencer.

The Electrical World will be glad, of course, to give space to Lieut. Spencer's courteous defense of the "Electrical Engineer," since he insists upon it, although I consider it very unwise in him to make these declarations.

I will begin by saying that the criticisms we published were intended merely as an exchange of editorial courtesies with our esteemed contemporary, and were not intended to reflect in any way upon either the electrical fountains themselves or upon Lieut. Spencer.

The "Engineer," however, seems to have a wonderful faculty for falling into holes of its own digging and drawing its friends in with it, and this seems to be but another instance in which its friends have been assisted in making themselves ridiculous by the freedom of its columns which has been so enticingly extended them.

Since Lieut. Spencer, however, has fathered the statements which I jokingly criticised, and throws down the gauntlet, I reiterate the statement that the present fountains are not constructed in accordance with the plans published in the "Electrical Engineer" of May 3, and if it is desired, stand prepared to specify wherein they differ, and thus to disprove the assertion that "There has been no deviation whatsoever from these plans."

Whether or not the plans published by the "Engineer" are those upon which the contracts were based is a matter with which I have nothing whatever to do. The plans and the fountains are not the same thing. We discussed the plans four months ago; the fountains we described in the issue of May 13.

The fact that the "Engineer's" article was approved and sanctioned by "those in authority" does not encourage one to rely very implicitly upon the infallibility of that authority. If the information gained from "improper, irresponsible parties" is more accurate than that sanctioned by "authority," wherein is one wise in choosing the latter?

As I was describing the fountains, I went to the fountains for my information, and I am not sorry now that I did.

The assertion that the data for the fountain article had been obtained "by methods of stealth and misrepresentation" is utterly false in every particular. The fountains were

open for public inspection, as many spectators are ready to testify. Like some other newspaper representatives, I visited the caissons, and the first time I was there, met both Lieut. Spencer and Mr. Stieringer. I thereafter visited the caissons almost daily during the preparation of the article, and not only made my sketches in the presence of employés of the General Electric Company, but frankly stated for what purpose they were made and when they were to appear. I was never questioned as to my right to be there or to make the sketches, and such questions as I chose to ask were freely answered.

When Mr. Johnston sent me Lieut. Spencer's letter, I at once called upon the lieutenant and asked him what he meant by the statement that I had gained entrance to the fountains by misrepresentation. To this he replied that one of his men had challenged my right to enter the caisson; but that on my statement that I had his (Lieut. Spencer's) permission, he had allowed me to remain, and I had stayed there a whole day. I replied that I never had been there so long as a day at a time, and that my right to enter had never been questioned. I added that neither his name nor that of anyone else had ever been used by me to gain either information or admission. I demanded that he confront me with his informant, and thus make good his accusation, or permit me to set myself right with the readers of The Electrical World and others interested; but this he declined to do.

This demand was made, not once or twice, but several times, but Lieut. Spencer has persistently refused to make known even the name of his informant. This, together with the fact that prior to my name being mentioned, another representative of The Electrical World in Chicago, who had never been inside of the fountain, was first accused of having used Lieut. Spencer's name to gain admission, will enable our readers to judge how much reliance can be placed upon the assertion.

I am told that Lieut. Spencer's judgment was seriously discredited in the eyes of his principals for having made public, as they thought, so much specific information as was given in The Electrical World's article. This I seriously regret, and have so expressed myself, and I wish now to hereby absolve him entirely from this responsibility by the statement that he gave me but one item of information in regard to the fountains, and of this I made no use, for I subsequently found it to be incorrect. I do not for a moment think the lieutenant knew it to be incorrect, but it proved so on investigation. Our contemporary did use it, however, and it is one of the statements that I criticised.

Lieutenant Spencer is also incorrect in his statement that in another instance where he had been compelled to refuse me certain diagrams I had used such information as I could get, contrary to his wishes. I acknowledged the justice of his refusal to furnish that information, and made no attempt whatever to get anything further on the subject, though it would have been possible for me to have secured it in an entirely legitimate way. I, however, did ask permission to use what I already had, and this was freely accorded. Not satisfied with Lieutenant Spencer's permission I immediately went to another gentleman high in authority as a representative of the General Electric Company, and also asked and obtained his consent.

The incompleteness of the information led me into a slight error in some curves; but as these were stated to be general and not specific, no great harm was done. This matter had nothing to do with the fountains, however, but applied to the Intramural Electric Railway.

I am very much amused at the "defense" which the "Electrical Engineer" makes in its issue of May 24. It prints a column article on the subject, signed G. B. M., and follows it by a copy of Lieut. Spencer's letter. This is a case where the broth has been spoiled by too many cooks. Either defence would have been good, if true, had it stood alone, but they can't both be true, for, if either is correct, the other must be wrong.

I wish to call attention to one or two of G. B. M.'s statements.

He thinks that The Electrical World is incorrect in stating that the "Electrical Engineer" should not have asserted that the lamps used consumed from 80 to 90 ampères. I did not say so, but I did criticise the statement that the lamps consumed "No less than 90 ampères each."

He emphasizes the words "spherical measurement" as applied to the quantity of light emitted by a "Holophote."

If he thinks this is incorrect he is less intelligent than I thought he was, for what else is the candle power from a parabolic reflector than the total or spherical illumination from the luminous point.

The engine signals which I gave were obtained from the gentlemen who had charge of the pumping station, and were those still in use when the article was written, and for aught I know are in force yet. They were probably as good as any other code of signals for the same purpose, though, of course, another code equally as appropriate could probably be easily devised. They were not copied from a code hanging in the engine room, as he states, but for all that may be identical. What I published was exactly what I claimed that they were—no more, no less.

G. B. M.'s defense of the twenty-four inch main claim is unique and worthy of preservation, and I refer our readers to the original if they are seeking amusement.

He says our sketches are creditably executed, but as engineering drawings worthless. So, it happens, are the "Engineer's" drawings worthless. Our sketches represent something, but what do those of the Engineer represent?

I admit that I was mistaken in the material of which the switchboard is composed. It is slate, not hard rubber. The next time I write up the fountain I will cheerfully make the correction. I also stand corrected as to which did the "throbbing" and "thrilling." I was under the impression that the spectator did both—that he thrilled while the fountain played, and throbbed when it didn't. I see now that I was mistaken, for G. M. B. says that the fountain does both. He, however, leaves us in doubt as to how long it should thrill and how long it should throb and as to whether it throbs when it is still or only thrills. Perhaps Mr. Martin, or whoever edited his copy, can tell us.

NELSON W PERRY.

CHICAGO, May 26, 1893.

Preliminary Programme of the International Electrical Congress.

The preliminary program of the International Electrical Congress, which is to be held in connection with the World's Columbian Exposition at Chicago, beginning August 21, 1893, signed by the Committee on Programme, of which Prof. J. C. Mendenhall is chairman, and Messrs. Carl Hering, A. E. Kennelly, and Profs. W. A. Anthony, H. A. Rowland, F. B. Crocker, E. L. Nichols, and H. S. Carhart are members, has been made public and is here given in full.

It might be stated that the General Congress will include a smaller body to be known as the Chamber of Delegates, which will consist of those specially designated as representative delegates from the various governments, appointed for the purpose of considering electric units and their values, and making recommendations as to the legalization of the same.

OPENING SESSION OF THE GENERAL CONGRESS, MONDAY, AUGUST 21, 3 O'CLOCK P. M.

ORDER OF BUSINESS.

1. The Congress will be called to order by the Chairman of the Local Committee, Dr. Elisha Gray, Highland Park, Ill. 2. Election of temporary chairman and secretary. 3. Appointment of a committee to nominate permanent officers. The officers will consist of a president, a vice-president for each nation sending delegates to the Chamber, a secretary. 4. Report of this committee. 5. Short addresses by the president, and by a few of the vice-presidents. 6. Announcements and adjournments.

At the close of this meeting, the Chamber of Delegates will assemble for preliminary organization, which will proceed as follows: 1. The Chamber will be called to order by one of the delegates representing the Uuited States. 2. Election of a temporary secretary. 3. Appointment of a committee of five on credentials. 4. Fixing a time for regular sessions. Adjournment. At the next meeting of the Chamber the committee on credentials will report, and a permapent organization will be completed.

DIVISION INTO SECTIONS.

The General Congress will be divided into three sections, as follows: A. The section of Pure Theory, including electric waves, theories of electrolysis, electric conduction, magnetism, etc. B. The section of Theory and Practice, including studies of dynamos, motors, storage batteries, measuring instruments, materials for standards, etc. C. The section of Pure Practice, including telegraphy and telephony, electric signaling, electric traction, transmission of power, systems of illumination, etc.

These sections will meet for organization and work at 10 a. m., Aug. 22. Their organization will consist of the election of a chairman, a vice-chairman, a secretary and a sectional committee of three in addition to the officers named above. Temporary presiding officers will be as follows: Section A, Prof. H. A. Rowland; Section B, Prof. Charles R. Cross; Section C, Prof. A. Graham Bell. Sections will meet at 10 o'clock a. m., on Tuesday, Wednesday, Thursday and Friday, continuing in session at will except on Friday, when they will finally adjourn as sections not later than 1 o'clock, p. m. Each section will have authority to divide into sub-sections if it is thought to be desirable.

Papers are solicited upon the following subjects, or upon other topics which may be considered suitable in character. They should be sent to the chairman of the Programme Committe not later than August 1, 1893. Such as are accepted by that committee will be put upon the programme of the Congress, to be presented in full or by abstract according to the time available:

Magnetic units and modes of embodying them in concrete standards.
Methods of avoiding electrical interference and risks to person and property.
National and municipal testing laboratories.
Materials for standards of electric resistance.
Points of difference of the electrical vocabulary used in different countries.
The direct conversion of the energy of fuel into electric energy.
Comparison of the various methods employed for the electric transmission of power.
The cost of insulation in relation to high pressure for the electric transmission of power.
Comparison of the economies of the various systems of electric distribution.
Alternating current motors.
The behavior of transformers when supplying power to alternate current motors.
The construction of condensers for alternating current purposes.
The measurement of power is polyphase currents.
Direct coupled and non-direct coupled dynamos.
The use of equalizing dynamos in a three and a five-wire system.
The use of accumulators in central stations.
The proportions between output of dynamos and the weight of copper and iron employed in their construction.
Electric traction.
Application of electric power in mining.
The adoption of a uniform method of distinguishing positive and negative mains.
Electric supply meters, American, British, Continental.
Criterion of sensibility of galvanometers.
Commercial instruments for measurement of electric quantities.
The relation between the voltage of the arc and the quality and composition of the carbons.
The ageing of glow lamps.
The electric working of metals.
The use of electric and magnetic tests for ascertaining the mechanical properties of metals and alloys.
The best material and mode of erection of lightning conductors in the light of recent researches in electric discharges.
The prospecting for iron by magnetic surveys.
International telegraphy.
Fast-speed and long-distance telegraphy.
The use of batteries or other generators for telegraphy.
Telegraphic lines—land and sea.
Harmonic telegraphy.
Writing telegraphs.
Long-distance telephony.
The possibility of providing telephonic communication without wires.
Application of electric signaling to the working of railways (alarms, time, etc.), and to naval and military purposes.
Magnetic separators.
The use of electricity in engraving and in art reproductions.

The time allotted to the discussion of the papers presented will be determined by the several sectional committees. In the discussion of papers the Chairman of the Section will name the first speaker.

THE CHAMBER OF DELEGATES.

The following topics will be considered by the Chamber of Delegates:

Adoptions of definitions and values of fundamental units of resistance, current and electromotive force.
Adoption of definitions and values of magnetic units.
Adoption of definition and value of the unit of self-induction.
Definitions and values of light, energy and other units.
The standardization of electric lights.
The consideration of an international system of notation and conventional symbols and of a more uniform and accurate use of terms and phrases in electrical literature.
A commercial standard of copper resistance.

Together with such other topics as may properly come before this body.

The hours of meeting for the Chamber of Delegates shall be determined, after the first session, by the Chamber itself; and it shall also decide upon the admission of persons not delegates to its sittings. It shall finally adjourn not later than 1 o'clock P. M. on Friday, Aug. 25, and at the last meeting of the General Congress the officers of the Chamber shall report to it a summary of its proceedings and the conclusions reached.

Public lectures of a popular character will be delivered by eminent electricians at 8 o'clock P. M., on Tuesday, Thursday and Friday of the Congress week.

The General Congress will assemble to hear reports and for final adjournment at 3 o'clock P. M. Friday, Aug. 25.

NEW BOOKS.

HOW TO MAKE INVENTIONS; OR INVENTING AS A SCIENCE AND AN ART. A Practical Guide for Inventors. By Edward P. Thompson, M. E. Illustrated by William A. Courtland. Second edition. Revised and enlarged. New York: D. Van Nostrand Co. 181 pages.

The second edition of Mr. E. P. Thompson's excellent treatise for inventors is considerably enlarged by the addition of new matter, and has been revised to bring its ideas and information to date. Every aspect of inventing is considered, from the abstract philosophical principles concerned to concise directions for preparing the patent papers. The collections of principles and hints under the head of different sciences are extremely valuable to the inventor, whether he uses them in the scientific manner developed by the author, or merely refers to them for data bearing on a subject in hand. The suggestions and directions so profusely scattered throughout the pages should prove of great value to every inventor, whether he is a practical man with little theoretical knowledge, or a theoretical man with little practical knowledge, or the happy mean. The mechanical execution of the work is not at all in keeping with the contents.

The May number of "The World's Fair Electrical Engineering" is before us, and is in many respects the best of the series, and reflects great credit on its editor and publisher. One of its most valuable features, which has reached its greatest development in this number, is the Synoptical Index of Current Electrical Literature. Some thirty-four pages are devoted to this, and give, under appropriate headings, the titles and authors of all articles of an electrical nature published during the preceding month. Not only this, but the general character of the articles is briefly outlined, and the date and place of publication and the approximate number of words are given. At the close, a list of the papers in which the preceding titles have appeared, with their addresses, are arranged alphabetically under the cities in which they are published in this country, and under the countries, where they are foreign publications. The value of this department will certainly be appreciated by its increasing circle of readers.

Technical Education in Europe.

BY FRANK C. PERKINS.

The subject of technical education has been treated by numerous writers in the electrical journals from time to time, and much interest has been manifested in this direction. A great deal of data has been given concerning the courses and methods used by the leading engineering schools in this country. The views of the buildings, laboratories and shops of these institutions have been of especial interest, and it must be acknowledged that the laboratories of the Stevens Institute, Cornell University, Massachusetts Institute of Technology and University of Michigan have electrical and mechanical equipments equal, if not superior, to any others in the world.

Very little data has been published in the American technical papers in reference to the polytechnical schools of Europe, and it may be of interest to study a few of the more prominent ones. Courses in physics and electrical and mechanical engineering are given in most of the large universities of England, France and Germany and there are a number of well equipped institutions in London, Paris, Berlin and other cities where courses in engineering and electricity are made a specialty. There is little doubt that Germany has by far more technical schools than any other European country. Among the most prominent are those at Dresden, Braunschweig, Darmstadt, Charlottenburg, Karlsruhe, Stuttgart, München and Leipzig. It is also conceded that the work accomplished by the students at Zurich, Switzerland; Vienna, Austria; and Berlin, Germany, indicates clearly that these institutions are among the best on the continent.

Electrical Engineering at the University of Berlin.

The University of Berlin has now registered in the various branches of study between six and seven thousand students. The University proper is situated on that beautiful promenade "Unter den Linden." The main building, a fair illustration of which is here given (Fig. 1), was formerly the palace of Prince Henry, brother of Frederick II. It was erected in 1754-64, and fitted up in 1809 for the University, which was founded about that time. The garden in front is embellished with statues of William and Alexander von Humboldt: To the University also belong the following buildings. The library, Dorotheen Strasse; the chemical laboratory, Georgen Strasse; and the new physiological and physical institutes, Neue Wilhelm Strasse. The latter being the department especially interesting to electricians, an illustration is given (Fig. 3) of one of the laboratories of the Physical Institute. In this building there are about one hundred students engaged in the study of the electrical science. Prof. Von Helmholtz lectures in this department in mathematical physics. The lectures in experimental physics are given by Prof. A. Kundt. It may be stated that for researches in physics this is one of the best equipped institutions in Germany.

The courses in electrical engineering are not directly connected with the University, but are taken up at the Technical College in Charlottenburg, a suburb of the city of Berlin.

The Technical School of Berlin-Charlottenburg.

The main building (Fig. 2) was constructed from the designs of Lucae and Raschdorff. It was five years in building and cost something over nine million marks, i. e., about two and one-half million dollars. It has been in use since the year 1884, and has at present over 1,800 students registered in the various departments. The several courses are: Civil engineering, railway engineering, mechanical engineering (including marine engineering), chemistry and architecture.

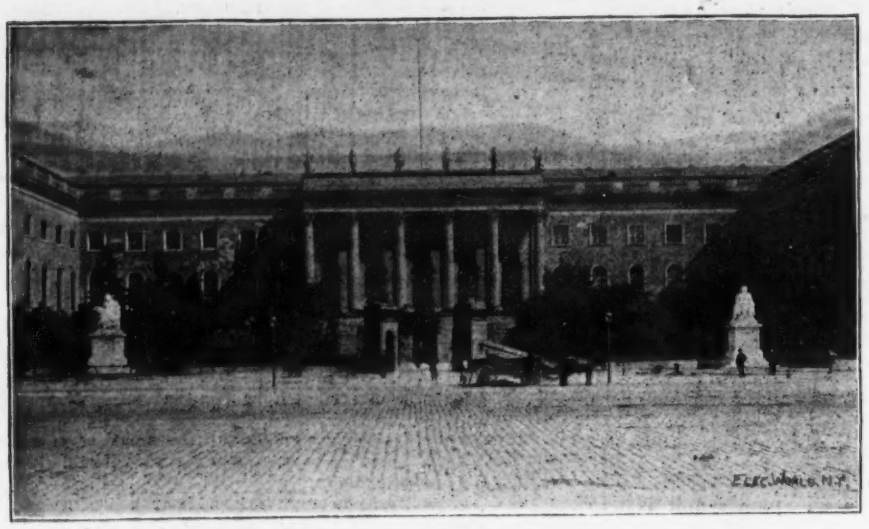


FIG. 1.—MAIN BUILDING OF THE UNIVERSITY OF BERLIN.

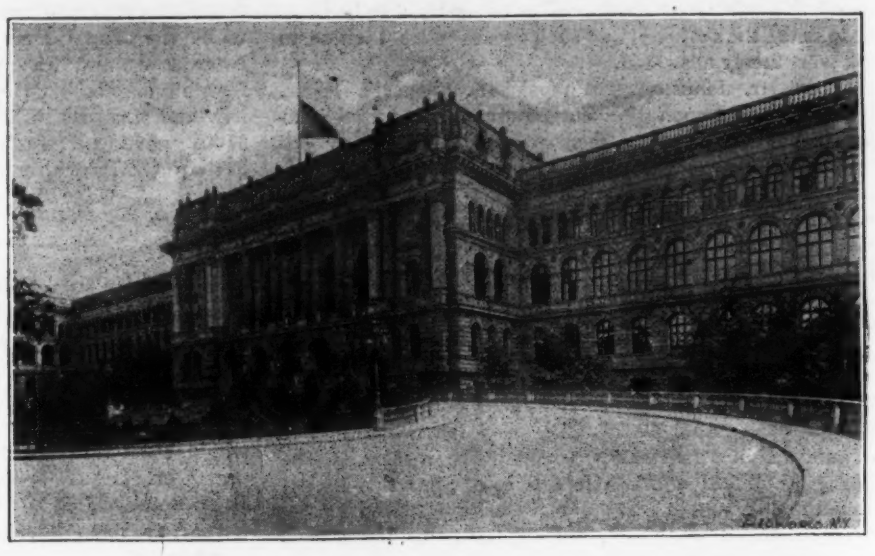


FIG. 2.—MAIN BUILDING OF THE TECHNICAL SCHOOL OF BERLIN-CHARLOTTENBURG.

FIG. 3.—One of the Laboratories of the Physical Institute.

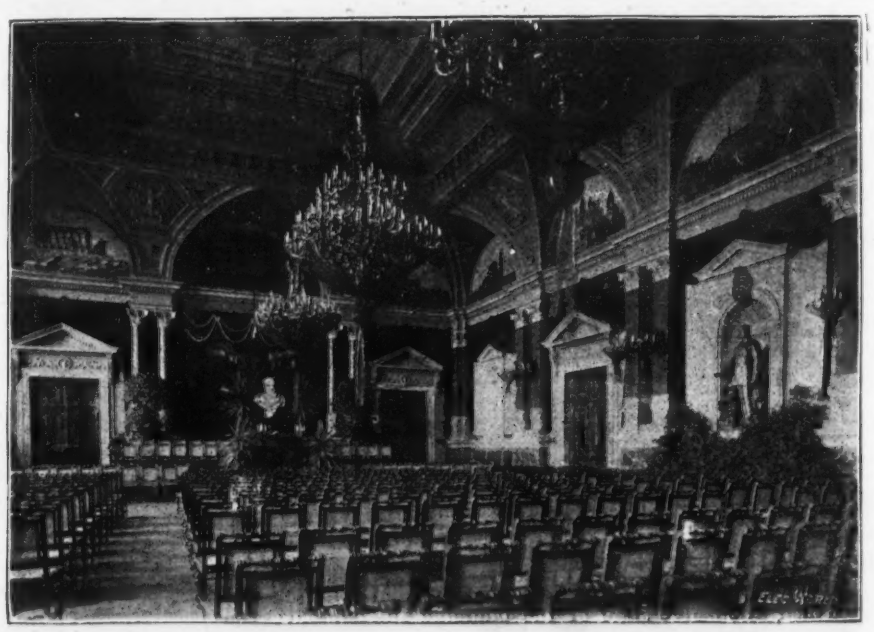
The instruction in the electrical science forms a part of the work in mechanical engineering. The professors state that they do not give the instruction in order that the students may become electricians only, the chief object being to prepare them to become electrical engineers, i. e., men competent to fill positions as practical engineers in the electrical industry. The electrical instruction is given by lectures of four hours per week during one year, and the subjects taken up are: Laws of Electrical Currents, Induction, Primary and Secondary Batteries, Dynamos (direct and alternating current), Electric Motors, Transformers, Electric Lighting Central Stations and Transmission of Power. Besides the lectures, exercises in practical measurements are given, and various tests are made in the electrical laboratory. The students are expected to make a careful study of all measurements that are required for practical purposes in working with batteries, dynamos, electric motors, photometry (life, candle power, etc., of incandescent and arc lamps) and transmission of power. Only the most practical experiments are given, and not such as one would be expected to take up in a course of applied physics. The lectures are given by Prof. Slaby, who also has charge of the work in electrical engineering. He is aided in the laboratory by two assistants, Dr. W. Wedding and Mr. H. Betlike.

The laboratories are occupied by 85 students, and are open the whole day from 8 A. M. to 5 P. M. Two mechanicians are employed, who make new instruments and repair such as get out of order in the course of the experimental work.

The corridor and lecture-room of the main building (Figs. 4 and 5), are of beautiful design, and embellished with statues, paintings, carvings and frescos, as will be noted by the accompanying illustrations.

There are seven laboratories in the department of electricity, which are well equipped with all the necessary apparatus for carrying on investigations in their special lines. The dynamo room covers about 150 square metres, and the power used for driving the electrical machines is derived from a gas engine having a capacity of 8 h. p. In the foreground will be seen the gasmeters, pressure regulators, tachometers, countershafting and several dynamos and motors of various designs. The power used for driving the smaller machines is obtained from a turbine of 3 h. p., one small water motor and three or four air engines. The dynamo electrical machinery with which this laboratory is equipped is of German manufacture and consists of three direct current dynamos built by Schuckert & Company, of Nürnberg; Lahmeyer & Company, of Aachen; and the Allgemeine Electricitäts Gesellschaft, of Berlin. There is also in the equipment a large direct current machine of special design, manufactured by Siemens & Halske, of Berlin, which may be used as a series machine, shunt machine or compound machine for experimental purposes by simply making the necessary changes in the connections of the various windings. A machine for generating direct currents, alternating currents and drehstrom or multiphase currents, with changeable frame or pole bases, has recently been constructed from the designs of Prof. Slaby, and is used for illustrating the principles governing these currents and the various connections necessary for their production. Among the smaller machines in the dynamo room are three direct current electric motors, and two alternating current machines, one built by Siemens & Halske, of Berlin, and the other by Ganz & Company, of Buda-Pesth. Two large transformers have also been furnished by these companies.

A room of 30 square metres is fitted up for a library and working-room of the assistants, and several laboratories of sizes varying from 80 square metres to 160 square metres



FIGS. 4 AND 5.—CORRIDOR AND LECTURE ROOM OF MAIN BUILDING.

are provided for experiments with mirror galvanometers, measurements of accumulators, measurements of resistances, and for magnetic researches.

The photometry-room is very conveniently arranged, and covers about 54 square metres. The equipment is especially fine, and among the various photometers in use are two by Lummer-Brodhun, one angle photometer by Bunsen-Elster, and several photometers designed by Bunsen, Weber, Beringer and others. In this room a study of arc and incandescent lamps, with reference to the life, candle-power, etc., is carried on with great interest and profit to the students.

The accompanying illustrations (Figs. 6 and 7) will give some idea of the junior laboratory in the electrical department.

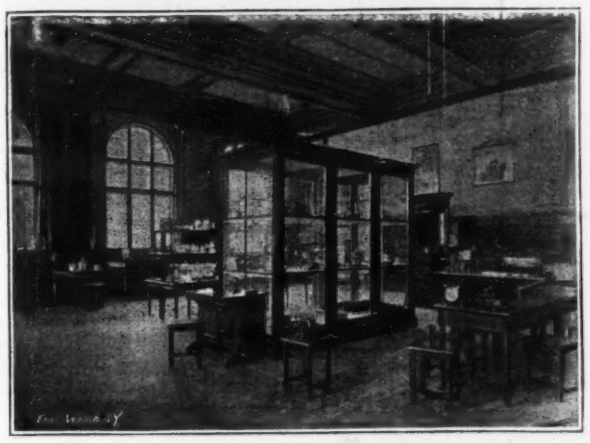
The mechanical workshops are fitted up with lathes, planers and other necessary machine tools, and many very fine instruments have been made in these shops.

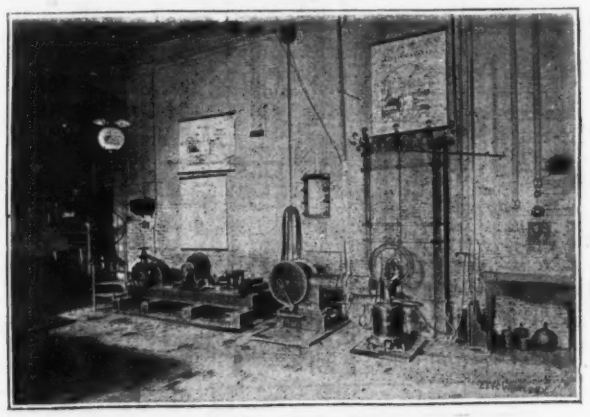
For demonstrative purposes there are in operation three telephone and three telegraph stations, with relays and all necessary switchboards and accessories.

The accumulator plant is very complete, and contains 25 cells each from the systems of Eppstein, Tudor, De Khotinsky and Pollack. A large number of primary batteries are also used, comprising 100 Bunsen elements, 50 Daniel cells, as well as a large number of gravity and Pollack cells.

The resistance bridges used in this institution are of the types of Thomson, Kohlrausch, Wheatstone and others; while for dynamo testing and other similar work large resistance of german silver and iron are employed.

The ammeters, voltmeters and other measuring instruments used in the laboratories are made from designs of Kapp, Schuckert, Kohlrausch, Siemens & Halske, General Electric Company of Berlin and the Weston Electrical Instrument Company of America.





FIGS. 6 AND 7.—THE JUNIOR LABORATORY.

Everything connected with the laboratories, workshops and lecture-rooms of the University is such as to inspire students to take advantage of the many opportunities there afforded.

Alternators in Parallel.

BY EMIL HUBER.

So much has been written about connecting alternators in parallel that your readers will doubtless be interested in some facts regarding the parallel connection of alternators under different circumstances. The machines referred to are multipolar, flat ring machines, of the Kapp type, for a frequency of 50 to 65, and were constructed by the Oerlikon Company, in Switzerland.

In Schio, Lugano, Bellinzona, Reichenhall and Macerata such machines for 50, 100 and 150 h. p. are driven, each with a separate turbine either directly coupled or by means of gear wheels. These machines are coupled in parallel without any load resistance as soon as the load on each of the machines is about 25 per cent. of the normal. The connection is made by observing the usual phase indicators as soon as synchronism is approximately established and after regulating for the voltage. In the central station at Zurich, where two machines of 300 h. p. have been running for a year and where two others of like size are in course of construction, the parallel coupling is accomplished by mechanical means without a phase indicator and without any artificial load resistance; the machine to be coupled is brought to approximately synchronous speed by means of a special high pressure turbine; the synchronous speed is observed by a man stationed at the clutch coupling by the relative motion of the teeth on the two parts of the coupling; the mechanical coupling takes place without jar or noise; the coupling of the circuits takes place after regulating the voltage by means of a double pole switch; there is no variation in the lights.

In the central station at Chur (Croire) a 400-h. p. turbine drives three alternators of 100 h. p. from a common shaft by means of belts; in this station experiments were made to determine at what load the parallel coupling can take place. It was found that they could be coupled without the use of any load resistances, when approximate synchronism was reached, and when the load was only 1⅜ ampères; that is, only 5½ per cent. of the normal load.

The ease with which these machines can be coupled shows itself also in their application as motors; one of the three machines in the Chur station runs a similar machine as a motor in a mill. This motor is started by a small 9-h. p. alternate current motor which starts with a load; when synchronism is reached, the motor is connected to the shafting of the mill. In spite of very variable loads this motor has never fallen out of synchronism for a mean load of 90 h. p.

In the recently started central station at Wasa, in Finland, there are two 100 h. p. alternators run with belts from two compound Oerlikon steam engines. The engineer, who started this station, had never been present at a parallel coupling of alternators, but notwithstanding this he succeeded without any trouble, which is a further proof that these alternators can be coupled in parallel very readily. In this installation, also, there is neither a load resistance nor a special regulator on the steam engine. The same may be said, also, of the multiphase alternators of this company. It is not the intention of this note to enter into the reasons why the coupling of these alternators is so easy, but only to give a practical example of cases where they are so run.

OERLIKON, May, 1893.

Electric Heating and Cooking.

Mr. S. B. Jenkins recently delivered an interesting lecture before the Chicago Electric Club which the American Electric Heating Corporation, of Boston, has had printed in pamphlet form.

Attention is called to the greater efficiency in the utilization of the heat furnished by an electric heater over a stove or range, the proportions being given as about 95 per cent. and 5 per cent. respectively.

An interesting feature of the lecture is the statistics given. Beef can be roasted in an electric heater at the rate of seven to seven and one-half minutes to the pound, and the heat is produced evenly all around the oven. the effect being so perfectly uniform that it is not necessary to baste the meat or turn the bread or cake while cooking. Broiling is difficult under ordinary circumstances, as an intense, clear fire is required, and care must be used to avoid smoking the meat, as that gives it a bitter flavor; the electric broiler meets all requisitions perfectly and easily, and steaks and chops are cooked in the usual time. Tea and coffee can be made from the cold in from six to ten minutes.

The cost of boiling one gallon of water from 40 Fahrenheit does not exceed two cents, at five cents per h. p. for power, by actual test. Some 500 heat units are expended in heating the vessel and in radiation so that the actual cost of the heat unit is in round numbers one one-thousandth of one cent.

In an oven 10 pounds of beef have been roasted, 2 loaves of bread baked, and 12 plates heated for serving, all in 90 minutes, "from the cold," with an expenditure of energy amounting to 1.5 h. p.-hours, or 1,119 watt-hours; this at five cents per horse-power hour is 7½ cents; or at 10 cents per horse-power hour is 15 cents. At the five-cent rate this oven costs about 2½ cents per hour, the first expense of "heating up" being gradually eliminated with each hour of continued service. Chops are cooked for one cent, an oyster stew made for one-half cent, tea and coffee for four-tenths of a cent, all in sufficient quantities for the ordinary table, the energy rate being five cents per horse-power hour.

Large electric cars are heated to 60 Fahr., under all weather conditions, with an average consumption of energy of 1,000 watts per hour, in the climate of Boston. This should be very satisfactory, though no exact figures of expense can be given, as the cost of power on electric railways is not stated. It is fair to assume that it costs not more than 40 cents per car-day of 18 hours. When electric cars are heated, they undoubtedly divert to themselves sufficient carriage patronage to pay for the heating.

The average well-built city house in a block requires an equipment for heating, on the basis of an expenditure of electrical energy of 1 h. p. per 1,200 cubic feet of space, though this amount is by no means required to be used continuously and is stated as a maximum.

Tyndall's estimates being accepted, that 6 per cent. or 780 heat units of the 13,000 in one pound of coal are utilized as a maximum, and assuming that 800 are now utilized, then 2,000 pounds of coal produces in useful effect 1,600,000 heat units.

One h. p. hour of electricity produces 2,562 heat units, and upon this basis the following comparative table of the useful heat from coal and that from electricity has been calculated.

A horse-power year is assumed to be 4,000 hours out of the 8,760 which the year contains.

EQUIVALENT USEFUL HEATING CAPACITY OF COAL AND ELECTRICITY.

Electricity.			Coal.
Per watt-hour.	Per h. p. hour.	Per h. p. year.	Per 2,000 lbs. delivered.
$.000013405	$0.001	$4.00	$0.624
.....	.002	8.00	1 248
.....	.003	12.00	1.872
.....	.004	16.00	2.496
.000067025	.005	20.00	3.12
.00008043	.006	24.00	3.741
.000093835	.007	28.00	4.368
.00010724	.008	32 00	4.992
.000120645	.009	36.00	5.61
.00013405	.01	40.00	6.24
.0002681	.02	80.00	12.48
.00040215	.03	120.00	18.72
.0005362	.04	160.00	24 96
.00067025	.05	200.00	31.20
.0008043	.06	240.00	37.44
.00093835	.07	280.00	.....
.0010724	.08	320.00	.....
.00120645	.09	360.00	.....
.0013405	.10	400.00	.....

In round numbers, electricity at $0.015 per h. p. hour, or $60 per horse power year of 4,000 hours (which is 11 hours per diem on an average), is equivalent in practical useful heating effect to coal at $6 per ton, and the coal must be hard coal of best quality, burned with good ordinary care and discretion. This is on the basis of a contract for power as follows: viz., consumer of power agrees to pay $60 per horse power per year, using it whenever he chooses—all the time if he desires—perhaps 8,760 hours; but the average use of the householder under average circumstances would be 4,000 hours only—or 11 hours per diem throughout the year, except in sections of the United States south of Mason and Dixon line, where it would average about 3,000 hours only.

The preceding estimate is for the heating of houses only; the cooking is on a different basis entirely, as electricity at five cents per h. p. hour will compete directly with coal at $5.50 per ton of 2,000 pounds.

Numerous forms of cooking apparatus are mentioned, and almost every conceivable household use seems to be already provided for; the utensils referred to are those manufactured by the American Electric Heating Corporation, of Boston.

The Variation in Economy of the Steam Engine Due to Variation in Load.*

BY PROF. R. C. CARPENTER.

The first part of Prof. Carpenter's paper is devoted to the development of a formula to express the variation in the use of steam by an engine when running under different loads. The fundamental proposition upon which the reasoning is based is as follows:

The steam consumed by an engine may be considered as composed of two parts, one part being that which would be required to do the work in a *perfect engine*, which is defined here as an engine working without waste of any available heat and whose efficiency is equal to the thermodynamical efficiency of an engine working within the same limits of temperature; the other part being that required to overcome the losses due to cylinder condensation and various wastes of the engine.

The efficiency of a perfect engine is represented by the formula $e = \frac{T_1 - T_2}{T}$, where T_1 and T_2 are the respective absolute temperatures of the entering and exhaust steam. As the equivalent in heat units per hour of a horse power is 2545, the perfect engine will use $\frac{2545}{e}$ heat units per hour, and as the available unit of heat in one pound of steam measured by the latent heat of the entering steam r, the steam required would be

$$\frac{2545}{e\ s} = \frac{2545}{\frac{T_1}{T_1 - T_2} s}, \qquad (1)$$

The standard engine adopted, however, differs from the perfect engine; the heat utilized is considered to be not represented by the latent heat s, but by a term $(\lambda - q_0)$, where λ is the total heat and q_0 the heat of the liquid in the exhaust steam, and the expression for the steam required by the standard engine per I. H. P. per hour becomes

$$\frac{2545}{\frac{T_1}{T_1 - T_2}(\lambda - q_0)} = p \qquad (2)$$

From formula (2) Table I. was computed, showing the pounds of dry steam and heat units per I. H. P. required by the standard engine, and in the discussion that follows all the steam used by the real engine in excess of that required by the standard engine is considered as waste.

A large number of examples is worked out by two different formulæ, and the results tabulated and the conclusion arrived at from a study of these that it may be considered proper to assume that the amount of steam used by an engine to supply the waste follows a law that may be expressed by the equation

$$y = b\sqrt{x} + p \qquad (3)$$

in which

p = the water rate of the standard engine;

b = the steam required to overcome the wastes of an engine at its most favorable load;

y = water rate for n horse power;

* Abstract of a paper read at the tenth general meeting of the American Institute of Electrical Engineers.

m = water rate for best horse power;

$x = \frac{m}{n}$ when n is less than m;

$x = \frac{n}{m}$ when n is greater than m;

and it follows that b + p = m.

Equation (3) can be reduced to the form

$$y = p\left(\frac{b}{p}\sqrt{x} + 1\right) = p(r\sqrt{x} + 1)$$

where r is a constant and equal to the ratio of the steam used by the standard and given engines under the most economical load.

To determine whether a coefficient, which should be nearly constant, could be found for each class of engine, a large number of engine tests were examined. The results seem to indicate that the coefficient r does not vary through wide limits, as will be seen by examination of the compilation of a large number of tests in Table II., made with various classes of engines.

The water consumption per indicated horse power as shown in Table II. for the various classes of engines differs greatly, yet when compared with that required for a perfect engine working between the same limits of temperatures the variation is considerably reduced.

pressure is increased, beyond a limit not yet definitely determined, the number of cylinders must be increased in order that the waste shall not increase unduly as compared with the steam usefully applied.

The results in Table II. also show what is to be considered as best results for the classes of engines described, and no doubt show somewhat smaller coefficients than may be expected in ordinary practice.

Table III. was compiled, with the assistance of Dr. R. H. Thurston, from a large number of tests, and shows the results which may reasonably be expected for a given class of engine in ordinary condition.

It will be noticed that the coefficients in Table III. are considerably higher than those shown in the actual table of tests (Table II.); they are, however, about the best results that makers would guarantee for the respective classes of engines, and presumably equal to the best results obtained in everyday use.

In column IV. is given the weight of steam power per I. H. P. per hour used to overcome the wastes of the engine. Column III. gives the water rate for the standard engine, and the values correspond to p in the general equation (2). Column IV. is the difference between columns II. and III.

From Table I., giving the water rate of the standard engine, and Table III., column IV., we can obtain the coefficients for predicting the probable economy of any engine working at any portion of its rated power.

The formula expressing the water consumption of any engine is therefore expressed by formula (3):

$$y = b\sqrt{x} + p \qquad (3)$$

The value of p is given in Table II., that of b in column IV. of Table III. As already explained, x can safely be taken as unity, when the engine is working at its rated horse power, unless the engine is known to be very much over or under rated; for it is the almost universal practice of American builders to design their engines to give the rated capacity at the most economical point of cut-off. For other loads let n equal the required horsepower, m the rated horse power, then $x = m \div n$ when n is less than m; $= n \div m$ when n is greater than m.

The use of the formula will be rendered evident by an example as follows:

Required the water rate of a simple Corliss engine with 80 pounds steam by gauge, and working against two pounds absolute back pressure; that is, with a vacuum of 10 pounds Rated horse power of engine supposed to be 100.

We have for this case

$$p = 9.8; \quad b = 13.7.$$

So that

$$y = 9.3 + 13.7\sqrt{x}$$

as the general equation.

The values of x would be taken as follows: When the engine is loaded to 10 per cent. of its rated capacity x = 10, at 25 per cent. x = 4, at 125 per cent. x = 1.25.

A computation made in this manner gives the probable water consumption in pounds per I. H. P. for various loads and classes of engines, which are given in Table IV.

From the figures given, it will be noted that the increase in water consumption is small, when the extreme variation in load is confined between the limits of one-half and one and one-half the load, which gives the best results, and that the water consumption increases much more rapidly for light than heavy loads.

In conclusion, the writer states that the paper is to be considered simply as the result of a study of a large number of tests of actual engines working under various conditions.

As to the final computations, their value depends upon agreement with actual tests. They are of course to be considered as only average results applying to well built engines, since they do not take into account differences due to poor or good construction, which in practice is of great importance, and may give results which may differ 10 per cent., or even more, from those given.

In addition to what has been already stated, it may be said that the general result of the study made would indicate that the more economical an engine, even when loaded at its best ratio of expansion, the less will be the change in economy due to increase or decrease of load, and I am fully satisfied that the results of actual tests provide a strong argument in favor of the most economical type of engine, even for conditions under which the load varies rapidly and through wide limits.

The coefficients may prove useful in pointing out the probable economy of an engine with its most economical load, and its modification due to change of load. It should be understood that the only claim for consideration that these values possess is due to agreement with the results of reliable and careful tests.

TABLE I.—POUNDS OF DRY STEAM AND B. T. U. PER I. H. P. REQUIRED BY THE STANDARD ENGINE.

Steam Pressure. Absolute.	Temperature of Steam. Fah.	Back Pressure 14.7 Pounds. [212°]			Back Pressure 5 Pounds. [162.3°]			Back Pressure 2 Pounds. [126.3°]		
		Thermal Efficiency per cent.	B. T. U. per I. H. P. per Minute.	Dry Steam per I. H. P. per Hour.	Thermal Efficiency per cent.	B. T. U. per I. H. P. per Minute.	Dry Steam per I. H. P. per Hour.	Thermal Efficiency per cent.	B. T. U. per I. H. P. per Minute.	Dry Steam per I. H. P. per Hour.
25	240	2.6	1620	100.05	10.9	388	22.8	16.9	251	14.2
30	250.3	5.35	740	48.8	12.4	340	20.0	17.4	244	13.7
40	267.1	7.55	560	34.2	14.7	287	16.8	19.3	220	12.4
50	280.9	9.2	465	28.0	15.95	266	15.4	20.8	204	11.4
60	292.5	10.55	400	24.0	17.25	245	14.2	22.1	192	10.8
70	302.7	11.8	364	21.8	18.4	230	13.2	23.0	184	10.2
75	307.4	12.4	340	20.6	18.9	224	12.85	23.6	180	9.95
80	311.8	12.95	328	19.7	19.5	217	12.5	23.9	178	9.85
90	320.0	13.85	306	18.3	20.5	206	11.85	24.6	172	9.55
100	327.6	14.7	288	17.3	21.1	200	11 5	25.6	165	9.10
125	344.1	16.4	259	15.5	22.7	187	10.7	27.0	156	8.62
150	358.2	17.85	240	14.1	24.0	177	9.9	28.4	149	8.17
175	370 6	19.1	221	13.0	25.1	169	9.55	29.4	144	7.90
200	381.7	20.2	208	12.4	26.2	162	9.20	30.3	140	7.6
				p			p			p

TABLE II.—TESTS OF COMPOUND AND TRIPLE EXPANSION ENGINES.

Steam pressure by gauge.	Back pressure absolute.	Diameter of cylinder.	Stroke.	Revolutions	I. H. P.	Water rate. By trial. Actual	Water rate. For a perfect engine.	Waste per I. H. P. per hour.	Ratio Actual to perfect.	Ratio waste to perfect.	Kind of engine—Authority.
Lbs.	Lbs.	Inches.	Inches.			a	p	a − p = r	a ÷ p	f = r ÷ p	
8	2.4	24 and 38	27	70.8	116	16.9	9.2	7.7	1.84	0.84	....Geo. Mair.
511	5.0	22 " 24	60	.....	716	19.36	10.7	8.7	1.81	0 81	Reynolds-Corliss...Barnes.
98	2	18 " 32	.....	.....	.....	13.26	8.8	4.5	1.53	0 53	" " Henthorn (cross comp.)
96	2	.....	.....	.....	999	14.5	8.9	5.6	1.63	0.63	" " Leavitt (tandem).
92.8	2	.....	.....	.....	270.5	16.1	9.0	7.1	1.78	0 78	Harris-Corliss. ... Hill.
124.8	2	19 " 38	48	.....	325	14.67	8.4	5.6	1.57	0 67	Reynolds Corliss (vert. comp.).
114	2	22 " 44	60	68	631	14.3	8.5	5.8	1.67	0.67	Harris-Corliss (twin comp.) Barnes.
130	6	9½ " 21	20	160	95.4	18.77	10.5	8.87	1.80	0.80	Lansing automatic, Albion.R.C.Carpenter
100	2	14 " 21	20	172	227	16.57	10.7	5.87	1.67	0 67	" " Lansing. "
112	14.7	9 " 16	14	465	114	23 13	15.4	7.73	1.49	0.49	Automatic McEwen (tandem), "
125	14.7	8 " 14	12	97	50	22.6	14.3	8.3	1.58	0.58	" " " "
80	15.0	14 " 21	20	150	69.6	32 8	17.8	15.0	1.83	0.83	Lansing automatic. "
119.9	2	21 " 42	40	37.69	253.4	15.08	8.4	7.5	1.80	0.80	Blake compound pump. Prof. Peabody.
											Triple Expansion.
128	2	14, 25 " 33	48	.....	515	12 94	8.2	4.74	1.57	0.57	Reynolds-Corliss..Leavitt and Henthorn.
192	2.2	5, 8 " 12	10, 10 and 15	278	55.15	12.68	7.6	5.08	1.62	0.62	Reynolds eng. with jackets. Osb. Reynolds
98	5	9½, 14 " 21	20	165	266	17 98	11.1	6.88	1.62	0.62	Lansing eng. auto. tandem. R.C.Carpenter
124.9	5	27, 46 " 70	60	16.6	787.8	12.675	8.3	4.37	1.52	0.52	Reynolds-Corliss pumping. Tested by Mr. Fiend.
											TEST OF SIMPLE ENGINES, NON-CONDENSING AND CONDENSING.
50	15	8	24	60.4	12.7	42.2	23.8	18.4	1.78	0.78	Corliss non-condensing..Dixwell.
95.8	15	18.02	48	75.3	137	25.6	16.8	9.1	1.54	0.54	Reynolds Corliss " Miller's Exposition.
96.1	15	18.03	48	75.8	134.3	23.9	16.7	7.2	1.46	0.46	Harris-Corliss " " "
96.3	15	18.26	48	76.1	140.0	24.9	16.6	8.3	1.50	0.50	Wheelock " " "
120	15	14.5	18	125.9	80 26	25.61	14.5	11.1	1.77	0.77	Hoadley's portable " "
77.4	15	12	14	245	75.8	30.9	18.1	12 8	1.66	0.66	Automatic McEwen. R. C. C.
90	15	17	30	83	.....	26 6	17.0	9.6	1.56	0.56	" " Denton and Jacobus
70	16	14	20	171	45.1	30.3	19.0	10.7	1.6	0.60	" Lansing...R. C. C.
											Condensing Engines.
95.8	4	18.02	48	75.4	162.3	20.6	10.8	9.8	1.83	0.83	Reynolds-Corliss.....Miller's Exposition.
96.1	4	18 03	48	75.4	165.6	19.4	10.4	9.0	1.86	0.86	Harris-Corliss..... " "
96.	3.5	18.26	48	74.8	158.4	19.5	10 3	9.2	1.84	0.84	Wheelock.
95.8	4.5	.....	.....	75.4	162.3	20.6	11.0	9.6	1.87	0.87	Reynolds-Corliss.
95.8	4.0	34	30	61.1	306.2	20.7	10.9	9.8	1.90	0 90	Gallatin engine..... C. E. Emery.

TABLE III.—USUAL WATER CONSUMPTION FOR BEST RATIO OF EXPANSION.

	I.	II.	III.	IV.	V.	VI.
Class of Engine.	Gauge pressure.	Water Rate. Actual engine.	Water Rate. For standard engine.	Waste per I. H. P. per hour.	Ratio of waste to that used by standard engine.	Average ratio as in column V.
	Lbs.	Lbs. per hour.	Lbs. per hour.	Lbs.		
Non-Condensing.		w	p	w-p=b	b ÷ p	
Small Throttling. ...	60	42.5	18.9	23 1	1.24	1.25
" "	80	40.0	17.8	22 2	1.26	
" Automatic.....	60	37.5	18.9	18.6	0.98	0.97
" "	80	35.0	17.8	17.2	0.96	
Medium "	80	32.0	17.8	14.2	0.79	0.79
" "	100	29.0	16.1	12.9	0.79	
Corliss Simple.....	80	30.0	17.8	12.2	0.68	0.68
" "	100	27.0	16.1	10.9	0.68	
Compound Automatic	100	26.0	16.1	9.8	0.62	0.62
" "	125	23.0	14.4	8.6	0.62	
Condensing Engines Vacuum 26 inches.:						
Corliss Simple.....	60	25.0	10.	15.0	1.50	
" "	80	23.0	9.3	13.7	1.47	1.48
" "	100	22.0	8.8	13.2	1.50	
Compound Automatic	80	20.0	9.3	10.7	1.16	
" "	100	19.0	8 8	10.2	1.15	1.14
" "	125	17.5	8.3	9.2	1.12	
Corliss Compound....	80	18.0	9.3	8.7	0.95	
" "	100	17.5	8.8	8.7	0.99	0.96
" "	125	16.0	8.3	7 7	0.93	
Triple Expansion.....	100	15.5	8.8	6.7	0.76	
" "	125	14.5	8 3	6.2	0.75	0.75
" "	150	13.75	7.9	5.85	0.75	

TABLE IV.—PROBABLE WATER CONSUMPTION FOR VARIOUS CLASSES OF ENGINES WITH DIFFERENT LOADS.

Class of engine. Value of x.	Gauge pressure.	General equation of steam consumption.	Ratio of load to rated capacity. 1/10	1/4	1/2	3/4	1	1¼	1½
			10	4	2	1.33	1	1.25	1.50
			Lbs. of water per I. H. P. per hour.						
Throttling, non-condensing	80	$22.2\sqrt{x} + 17.8$	88.8	61.5	49.6	43.7	40.0	42.8	45.2
Automatic "	80	$14.2\sqrt{x} + 17.8$	63 0	46.2	37.9	34.2	32.0	33.7	35.2
" "	100	$12.9\sqrt{x} + 16.1$	56.8	41.9	34.4	31.0	29.0	30.5	31.9
Corliss simple, "	80	$12.2\sqrt{x} + 17.8$	56.4	42.2	35.1	31.9	30.0	31.5	32.8
Compound automatic, non-condensing	100	$9.8\sqrt{x} + 16.1$	47.1	35 7	30.0	27.5	25.9	27.1	28.1
" " "	125	$8.6\sqrt{x} + 14.4$	41.6	31.6	26.6	24.3	23.0	24.0	24.9
Corliss simple, condensing	80	$13.7\sqrt{x} + 9.3$	51.5	36.7	28.7	25.1	23.0	24.6	26.1
Compound automatic, condensing	100	$10.2\sqrt{x} + 8.8$	41.0	29.2	23.2	20.6	19.0	20.2	21.3
" " "	125	$9.2\sqrt{x} + 8.3$	37.3	26.7	21.3	18.9	17.5	18.6	19.6
Corliss compound "	100	$8.7\sqrt{x} + 8.8$	36.4	26 3	21.1	18.8	17.5	18.5	19.5
" " "	125	$7.7\sqrt{x} + 8.3$	32.7	23.7	19.2	16.6	16 0	16.9	17.7
Triple expansion	125	$6.2\sqrt{x} + 8.3$	27.9	20.7	17.1	15.5	14.5	15.2	15.9
" "	150	$5 85\sqrt{x} + 7.9$	26.4	19.6	16.2	14.6	13.75	14.4	17.1

On Light and Other High Frequency Phenomena.*

BY NIKOLA TESLA.

INTRODUCTORY.—SOME THOUGHTS ON THE EYE.

When we look at the world around us, on Nature, we are impressed with its beauty and grandeur. Each thing we perceive, though it may be vanishingly small, is in itself a world, that is, like the world of the visible universe, matter and force governed by law—a world, the contemplation of which fills us with feelings of wonder and irresistibly urges us to ceaseless thought and inquiry. But in all this vast world, of all objects our senses reveal to us, the most marvelous, the most appealing to our imagination, appears no doubt a highly developed organism, a thinking being. If there is anything fitted to make us admire Nature's handiwork, it is certainly this inconceivable structure, which performs its innumerable motions in obedience to external influence. To understand its workings, to get a deeper insight into this Nature's masterpiece, has ever been for thinkers a fascinating aim, and after many centuries of arduous research men have arrived at a fair understanding of the functions of its organs and senses. Again, in all the perfect harmony of its parts, of the parts which constitute the material or tangible of our being, of all its organs and senses, the eye is the most wonderful. It is the most precious, the most indispensable of our receptive or directive organs, it is the great gateway through which all knowledge enters the mind. Of all our organs it is the one which is in the most intimate relation with that which we call intellect. So intimate is this relation, that it is often said that the very soul shows itself in the eye.

NIKOLA TESLA.

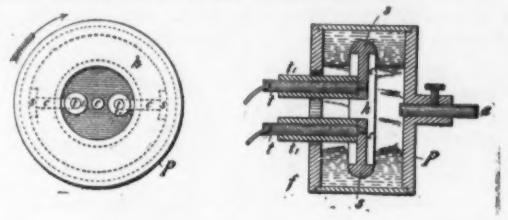
It can be taken as a fact which the theory of the action of the eye implies, that for each external impression, that is, for each image produced upon the retina, the ends of the visual nerves, concerned in the conveyance of the impression to the mind, must be under a peculiar stress or in a vibratory state. It now does not seem improbable that, when by the power of thought an image is evoked, a distinct reflex action, no matter how weak, is exerted upon certain ends of the visual nerves, and therefore upon the retina. Will it ever be within human power to analyze the condition of the retina when disturbed by thought or reflex action, by the help of some optical or other means of such sensitiveness that a clear idea of its state might be gained at any time? If this were possible, then the problem of reading one's thoughts with precision, like the characters of an open book, might be much easier to solve than many problems belonging to the domain of positive physical science in the solution of which many, if not the majority, of scientific men implicitly believe. Helmholtz has shown that the fundi of the eyes are themselves luminous, and he was able to see, in total darkness, the movement of his arm by the light of his own eyes. This is one of the most remarkable experiments recorded in the history of science, and probably only a few men could satisfactorily repeat it, for it is very likely that the luminosity of the eyes is associated with uncommon activity of the brain and great imaginative power. It is fluorescence of brain action, as it were.

Another fact having a bearing on this subject which has probably been noted by many, since it is stated in popular expressions, but which I cannot recollect to have found chronicled as a positive result of observation, is that at times, when a sudden idea or image presents itself to the intellect, there is a distinct and sometimes painful sensation of luminosity produced in the eye, observable even in broad daylight.

The saying then that the soul shows itself in the eye is deeply founded, and we feel that it expresses a great truth. It has a profound meaning even for one who, like a poet or artist, only following his inborn instinct or love for Nature, finds delight in aimless thoughts and in the mere contemplation of natural phenomena, but a still more profound meaning for one who, in the spirit of positive scientific investigation, seeks to ascertain the causes of the effects. It is principally the natural philosopher, the physicist, for whom the eye is the subject of the most intense admiration.

Two facts about the eye must forcibly impress the mind of the physicist, notwithstanding he may think or say that it is an imperfect optical instrument, forgetting that the very conception of that which is perfect, or seems so to him, has been gained through this same instrument. First, the eye is, as far as our positive knowledge goes, the only organ which is directly affected by that subtile medium which, as science teaches us, must fill all space; secondly, it is the most sensitive of our organs, incomparably more sensitive to external impressions than any other.

The organ of hearing implies the impact of ponderable bodies, the organ of smell the transference of detached material particles, and the organs of taste and of touch or force, the direct contact, or at least some interference of ponderable matter, and this is true even in those instances of animal organisms, in which some of these organs are developed to a degree of truly marvelous perfection. This being so, it seems wonderful that the organ of sight solely should be capable of being stirred by that which all our other organs are powerless to detect, which yet plays an essential part in all natural phenomena, which transmits all energy and sustains all motion, and, that most intricate of all, life, but which has properties such that even a scientifically trained mind cannot help drawing a distinction between it and all that is called matter. Considering merely this, and the fact that the eye, by its marvelous power, widens our otherwise very narrow range of perception far beyond the limits of the small world which is our own, to embrace myriads of other worlds, suns and stars in the infinite depths of the universe, would make it justifiable to assert that it is an organ of a higher order. Its performances are beyond comprehension. Nature, as far as we know, never produced anything more wonderful. We can get barely a faint idea of its prodigious power by analyzing what it does and by comparing. When ether waves impinge upon the human body, they produce the sensations of warmth or cold, pleasure or pain, or perhaps other sensations of which we are not aware, and any degree or intensity of these sensations, which degrees are infinite in number, hence an infinite number of distinct sensations. But our sense of touch, or our sense of force, cannot reveal to us these differences in degree or intensity, unless they are very great. Now we can readily conceive how an organism, such as the human in the eternal process of evolution, or, more philosophically speaking, adaptation to Nature, being constrained to the use of only the sense of touch or force, for instance, might develop this sense to such a degree of sensitiveness or perfection that it would be capable of distinguishing the minutest differences in the temperature of a body even at some distance, to a hundredth, or thousandth, or millionth part of a degree Yet, even this apparently impossible performance would not begin to compare with that of the eye, which is capable of distinguishing and conveying to the mind in a single instant innumerable peculiarities of the body, be it in form or color or other respects. This power of the eye rests upon two things, namely, the rectilinear propagation of the disturbance by which it is affected, and upon its sensitiveness. To say that the eye is sensitive is not saying anything. Compared with it, all other organs are monstrously crude. The organ of smell which guides a dog on the trail of a deer, the organ of touch or force which guides an insect in its wanderings, the organ of hearing, which is effected by the slightest disturbances of the air, are sensitive organs, to be sure, but what are they compared with the human eye! No doubt it responds to the faintest echoes or reverberations of the medium; no doubt, it brings us tidings from other worlds, infinitely remote, but in a language we cannot as yet always understand. And why not? Because we live in a medium filled with air and other gases, vapors and a dense mass of solid particles flying about. These play an important part in many phenomena; they fritter away the energy of the vibrations before they can reach the eye; they too, are the carriers of germs of destruction, they get into our lungs and other organs, clog up the channels and imperceptibly, yet inevitably, arrest the stream of life. Could we but do away with all ponderable matter in the line of sight of the telescope, it would reveal to us undreamt of marvels. Even the unaided eye, I think, would be capable of distinguishing in the pure medium small objects at distances measured probably by hundreds or perhaps thousands of miles.



FIGS. 4a AND 4b.—FORM OF DISCHARGER WITH LIQUID INTERRUPTER.

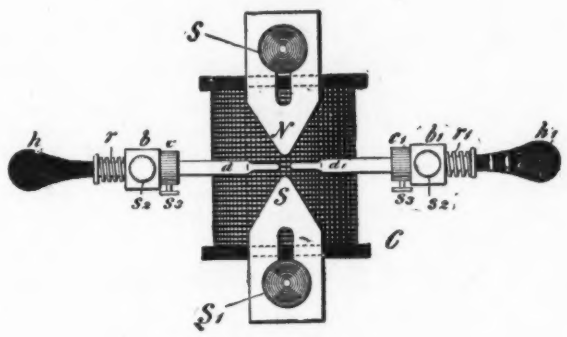


FIG. 2.—FORM OF DISCHARGER WITH MAGNET USED IN THE DIRECT CURRENT CONVERSION.

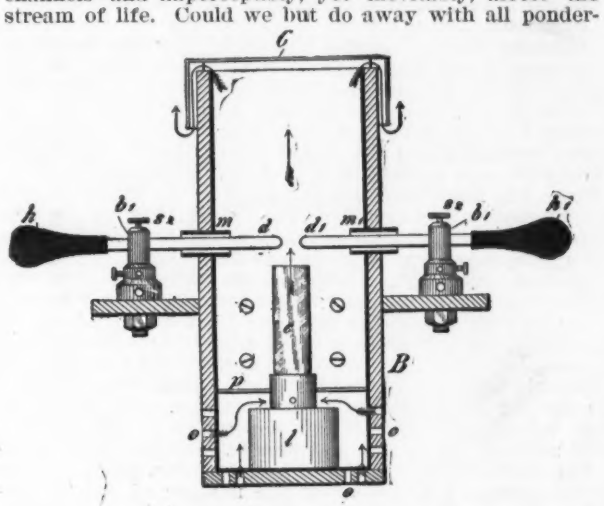


FIG. 3.—DISCHARGES WITH HOT AIR DRAFT.

But there is something else about the eye which impresses us still more than these wonderful features which we observe, viewing it from the standpoint of a physicist, merely as an optical instrument—something which appeals to us more than its marvelous faculty of being directly affected by the vibrations of the medium, without interference of gross matter, and more than its inconceivable sensitiveness and discerning power It is its significance in the processes of life. No matter what one's views on Nature and life may be, he must stand amazed when, for the first time in his thoughts, he realizes the importance of the eye in the physical processes and mental performances of the human organism. And how could it be otherwise, when he realizes that the eye is the means through which the human race has acquired the entire knowledge it possesses, that it controls all our motions, more still, all our actions.

There is no way of acquiring knowledge except through the eye. What is the foundation of all philosophical systems of ancient and modern times, in fact of all the philosophy of man? I am, I think; I think, therefore I am. But how could I think and how would I know that I exist, if I had not the eye? For knowledge involves consciousness; consciousness involves ideas, conceptions; conceptions involve pictures or images, and images the sense of vision, and therefore the organ of sight. But how about blind men, will be asked? Yes, a blind man may depict in magnificent poems forms and scenes from real life, from a world he physically does not see. A blind man may touch the keys of an instrument with unerring precision, may build the fastest boat, may discover and invent, calculate and construct, may do still greater wonders—but all the blind men who have done such things have descended from those who had seeing eyes. Nature may reach the same result in many ways. Like a wave in the physical world, in the infinite ocean of the medium which pervades all, so in the world of organisms, in life, an impulse started proceeds onward, at times, maybe with the speed of light, at times, again, so slowly that for ages and ages it seems to stay, passing through processes of a complexity inconceivable to men, but in all its forms, in all its stages, its energy ever and ever integrally present. A single ray of light from a distant star falling upon the eye of a tyrant in bygone times may have altered the course of his life, may have changed the destiny of nations, may have transformed the surface of the globe, so intricate, so inconceivably complex are the processes in

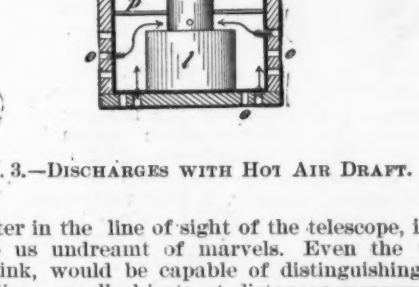


FIG. 5.—ILLUSTRATING THE EFFECT OF VARYING ELECTROSTATIC FORCE WITH A TRANSFORMER OF 200,000 VOLTS PRESSURE.

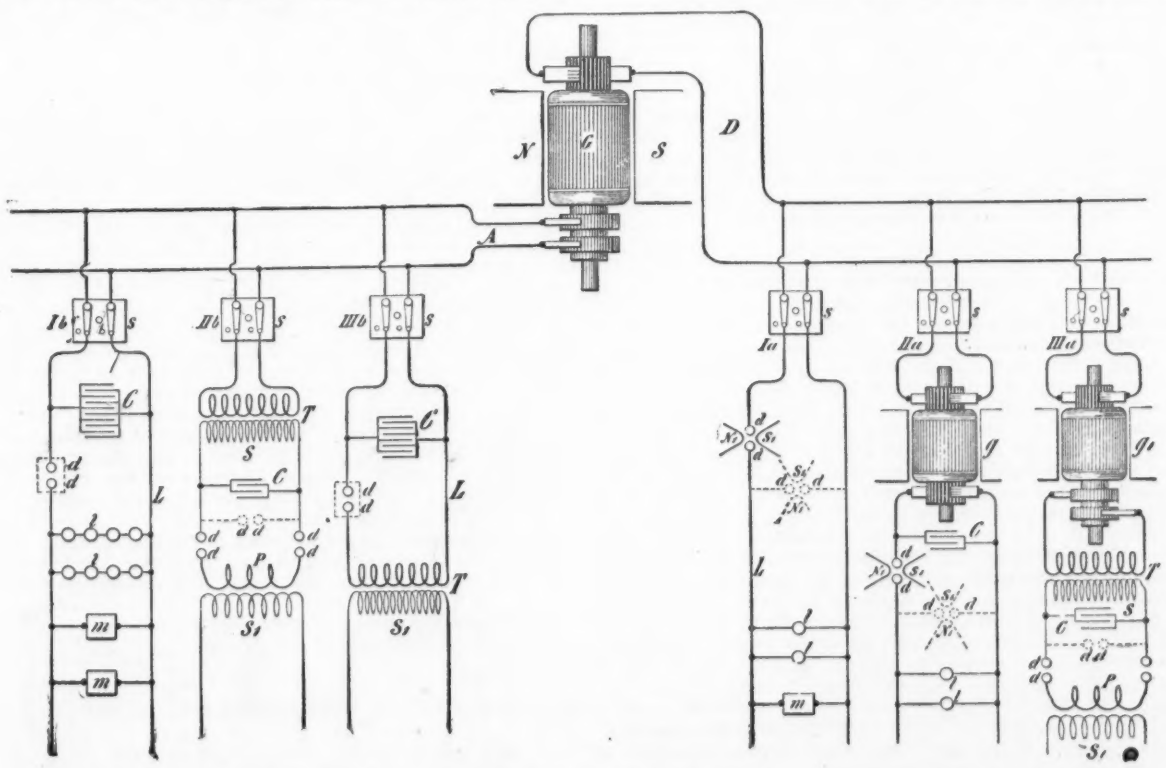
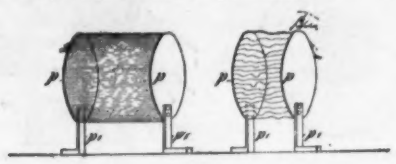


FIG. 1.—PLAN OF CONNECTIONS USED IN THE CONVERSION BY MEANS OF THE DISRUPTIVE ARC DISCHARGE.

* A lecture delivered before the Franklin Institute, at Philadelphia, Feb. 24, 1893, and before the National Electric Light Association, at St. Louis, Mo., March 1, 1893.

Nature. In no way can we get such an overwhelming idea of the grandeur of Nature than when we consider that in accordance with the law of the conservation of energy, throughout the infinite, the forces are in a perfect balance, and hence the energy of a single thought may determine the motion of a universe. It is not necessary that every individual, not even that every generation or many generations, should have the physical instrument of sight, in order to be able to form images and to think, that is, form ideas or conceptions; but sometime or other, during the process of evolution, the eye certainly must have existed, else thought, as we understand it, would be impossible; else conceptions,



FIGS. 6a AND 6b.—ILLUSTRATING THE EFFECTS OF RAPIDLY VARYING AND STEADY ELECTROSTATIC FORCE.

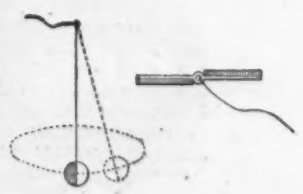
like spirit, intellect, mind, call it as you may, could not exist. It is conceivable that in some other world, in some other beings, the eye is replaced by a different organ, equally or more perfect, but these beings cannot be men.

Now what prompts us to all voluntary motions and actions of any kind? Again the eye. If I am conscious of the motion, I must have an idea of conception, that is, an image, therefore the eye. If I am not precisely conscious of the motion, it is because the images are vague or indistinct, being blurred by the superimposition of many. But when I perform the motion, does the impulse which prompts me to the action come from within or from without? The greatest physicists have not disdained to endeavor to answer this and similar questions, and have at times abandoned themselves to the delights of pure and unrestrained thought. Such questions are generally considered not to belong to the realm of positive physical science, but will before long be annexed to its domain. Helmholtz has probably thought more on life than any modern scientist. Lord Kelvin expressed his belief that life's process is electrical, and that there is a force inherent to the organism and determining its motions. Just as much as I am convinced of any physical truth I am convinced that the motive impulse must come from the outside. For, consider the lowest organism we know—and there are probably many lower ones—an aggregation of a few cells only. If it is capable of voluntary motion, it can perform an infinite number of motions, all definite and precise. But now a mechanism consisting of a finite number of parts, and a few at that, cannot perform an infinite number of definite motions, hence the impulses which govern its movements must come from the environment. So the atom, the ulterior element of the universe's structure, is tossed about in space eternally, a play to external influences, like a float in a troubled sea. Were it to stop its motion it would die. Matter at rest, if such a thing could exist, would be matter dead. Death of matter! Never has a sentence of deeper philosophical meaning been uttered. This is the way in which Prof. Dewar forcibly expresses it in the description of his admirable experiments, in which liquid oxygen is handled as one handles water, and air at ordinary pressure is made to condense and even to solidify by the intense cold. Experiments, which serve to illustrate, in his language, the last feeble manifestations of life, the last quiverings of matter about to die. But human eyes shall not witness such death. There is no death of matter, for throughout the infinite universe all has to move, to vibrate; that is, to live.

I have made the preceding statements at the peril of treading upon metaphysical ground in my desire to introduce the subject of this lecture in a manner not altogether uninteresting, I may hope, to an audience such as I have the honor to address. But, now then, returning to the subject, this divine organ of sight, this indispensable instrument for thought and all intellectual enjoyment, which lays open to us the marvels of this universe, through which we have acquired what knowledge we possess, and which prompts us to, and controls, all our physical and mental activity. By what is it affected? By light! What is light?

We have witnessed the great strides which have been made in all departments of science in recent years. So great have been the advances that we cannot refrain from asking ourselves, Is this all true, or is it but a dream? Centuries ago men have lived, have thought, discovered, invented, and have believed that they were soaring, while they were merely proceeding at a snail's pace. So we, too, may be mistaken. But taking the truth of the observed events as one of the implied facts of science, we must rejoice in the immense progress already made, and still more in the anticipation of what

FIG. 7.—BREAKING A BULB ON OPEN CIRCUIT.



FIGS. 8a AND 8b.—MECHANICAL MOTIONS PRODUCED BY VARYING ELECTROSTATIC FORCE IN A GASEOUS MEDIUM.

must come, judging from the possibilities opened up by modern research. There is, however, an advance which we have been witnessing, which must be particularly gratifying to every lover of progress. It is not a discovery, or an invention, or an achievement in any particular direction. It is an advance in all directions of scientific thought and experiment. I mean the generalization of the natural forces and phenomena, the looming up of a certain broad idea on the scientific horizon. It is this idea which has, however, long ago taken possession of the most advanced minds, to which I desire to call your attention, and which I intend to illustrate, in a general way, in these experiments, as the first step in answering the question. "What is light?" and to realize the modern meaning of this word.

It is beyond the scope of my lecture to dwell upon the subject of light in general, my object being merely to bring presently to your notice a certain class of light effects and a number of phenomena observed in pursuing the study of these effects. But to be consistent in my remarks it is necessary to state that according to that idea, now accepted by the majority of scientific men as a positive result of theoretical and experimental investigation, the various forms or manifestations of energy which were generally designated as "electric," or more precisely "electromagnetic," are energy manifestations of the same nature as those of radiant heat and light. Therefore, the phenomena of light and heat, and others besides these, may be called electrical phenomena. Thus electrical science has become the mother science of all, and its study has become all important. The day when we shall know what "electricity" is will chronicle an event probably greater, more important than any other recorded in the history of the human race. The time will come when the comfort, the very existence perhaps of man will depend upon that wonderful agent. For our existence and comfort we require heat, light and mechanical power. How do we now get all these? We get them from fuel, we get them by consuming material. What will man do when the forests disappear? when the coalfields are exhausted? Only one thing, according to our present knowledge will remain; that is, to transmit power at great distances. Men will go to the waterfalls, to the tides, which are the stores of an infinitesimal part of Nature's immeasurable energy. There will they harness the energy and transmit the same to their settlements, to warm their homes by, to give them light, and to keep their obedient slaves, the machines, toiling. But how will they transmit this energy if not by electricity? Judge then, if the comfort, nay, the very existence, of man will not depend on electricity. I am aware that this view is not that of a practical engineer, but neither is it that of an illusionist, for it is certain that power transmission, which at present is merely a stimulus to enterprise, will some day be a dire necessity.

It is more important for the student who takes up the study of light phenomena to make himself thoroughly acquainted with certain modern views, than to peruse entire books on the subject of light itself, as disconnected from these views. Were I, therefore, to make these demonstrations before students seeking information—and for the sake of the few of those who may be present, give me leave to so assume—it would be my principal endeavor to impress these views upon their minds in this series of experiments.

It might be sufficient for this purpose to perform a simple and well known experiment. I might take a familiar appliance, a Leyden jar, charge it from a frictional machine, and then discharge it. In explaining to you its permanent state when charged, and its transitory condition when discharging, calling your attention to the forces which enter into play and to the various phenomena they produce, and pointing out the relation of the forces and phenomena, I might fully succeed in illustrating that modern idea. No doubt, to the thinker, this simple experiment would appeal as much as the most magnificent display. But this is to be an experimental demonstration, and one which should possess, besides instructive, also entertaining features, and, as such, a simple experiment, such as the one cited, would not go very far toward the attainment of the lecturer's aim. I must, therefore, choose another way of illustrating, more spectacular, certainly, but perhaps also more instructive. Instead of the frictional machine and Leyden jar I shall avail myself in these experiments of an induction coil of peculiar properties, which was described in detail by me in a lecture before the London Institution of Electrical Engineers, in February, 1892. This induction coil is capable of yielding currents of enormous potential differences, alternating with extreme rapidity. With this apparatus I shall endeavor to show you three distinct classes of effects, or phenomena, and it is my desire that each experiment, while serving for the purposes of illustration, should, at the same time, teach us some novel truth, or show us some novel aspect of this fascinating science. But before doing this it seems proper and useful to dwell upon the apparatus employed, and method of obtaining the high potentials and high frequency currents which are made use of in these experiments.

ON THE APPARATUS AND METHOD OF CONVERSION.

These high frequency currents are obtained in a peculiar manner. The method employed was advanced by me about two years ago in an experimental lecture before the American Institute of Electrical Engineers. A number of ways, as practiced in the laboratory, of obtaining these currents, either from continuous or low frequency alternating currents, is diagrammatically indicated in Fig. 1, which will be later described in detail. The general plan is to charge condensers, from a direct or alternate current source, preferably of high tension, and to discharge them disruptively while observing well known conditions necessary to maintain the oscillations of the current. In view of the general interest taken in high frequency currents and effects producible by them, it seems to me advisable to dwell at some length upon this method of conversion. In order to give you a clear idea of the action, I will suppose that a continuous current generator is employed, which is often very convenient. It is desirable that the generator should possess such high tension as to be able to break through a small air space. If this is not the case, then auxiliary means have to be resorted to, some of which will be indicated subsequently. When the condensers are charged to a certain potential, the air, or insulating space, gives way and a disruptive discharge occurs. There is then a sudden rush of current, and generally a large portion of the accumulated electrical energy spends itself. The condensers are thereupon quickly charged, and the same process is repeated in more or less rapid succession. To produce such sudden rushes of current it is necessary to observe certain conditions. If the rate at which the condensers are discharged is the same as that at which they are charged, then, clearly, in the assumed case the condensers do not come into play. If the rate of discharge be smaller than the rate of charging, then, again, the condensers cannot play an important part. But if, on the contrary, the rate of discharging is greater than that of charging, then a succession of rushes of current is obtained. It is evident that, if the rate at which the energy is being dissipated by the discharge is very much greater than the rate of supply to the condensers, the sudden rushes will be comparatively few, with long time intervals between. This always occurs when a condenser of considerable capacity is charged by means of a comparatively small machine. If the rates of supply and dissipation are not widely different, then the rushes of current will be in quicker succession, and this the more, the more nearly equal both the rates are, until natural limitations incident to each case and depending upon a number of causes are reached. Thus we are able to obtain from a continuous-current generator as rapid a succession of discharges as we like. Of course, the higher the tension of the generator, the smaller need be the capacity of the condensers, and for this reason, principally, it is of advantage to employ a generator of very

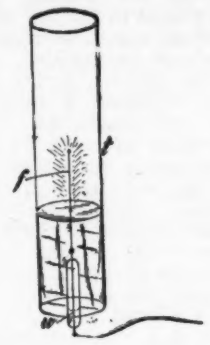


FIG. 9.—SHOWING THE EFFECT OF THE AIR.

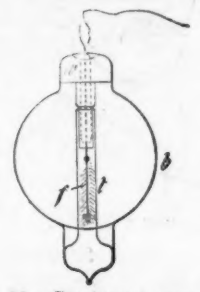


FIG. 10.—SHOWING THE INFLUENCE OF THE CONDUCTIVITY OF THE MEDIUM UPON ELECTROSTATIC ACTIONS THROUGH MEASURABLE DISTANCE.

high tension. Besides, such a generator permits the attaining of greater rates of vibration.

The rushes of current may be of the same direction under the conditions before assumed, but most generally there is an oscillation superimposed upon the fundamental vibration of the current. When the conditions are so determined that there are no oscillations, the current impulses are unidirectional and thus a means is provided of transforming a continuous current of high tension into a direct current of lower tension, which I think may find employment in the arts.

This method of conversion is exceedingly interesting and I was much impressed by its beauty when I first conceived it. It is ideal in certain respects. It involves the employment of no mechanical devices of any kind, and it allows of obtaining currents of any desired frequency from an ordinary circuit, direct or alternating. The frequency of the fundamental discharges depending on the relative rates of supply and dissipation can be readily varied within wide limits by simple adjustments of these quantities, and the frequency of the superimposed vibration by the determination of the capacity, self-induction and resistance of the circuit. The potential of the currents, again, may be raised as high as any insulation is capable of withstanding safely by combining capacity and self-induction or by induction in a secondary, which need have but comparative few turns.

As the conditions are often such that the intermittance or oscillation does not readily establish itself, especially when a direct current source is employed, it is of advantage to associate an interrupter with the arc, and I have, some time ago, indicated the use of an air-blast or magnet, or other such device readily at hand. The magnet is employed with special advantage in the conversion of direct currents, as it is then very effective. If the primary source is an alternate current generator, it is desirable, as I have stated on another occasion, that the frequency should be low, and that the currents forming the arc be large, in order to render the magnet more effective.

A form of such discharger with a magnet which has been found convenient, and adopted after some trials, in the conversion of direct currents particularly, is illustrated in Fig. 2. N S are the pole pieces of a very strong magnet which is excited by a coil C. The pole pieces are slotted for adjustment and can be fastened in any position by screws s_1 s_1. The discharge rods d d_1 thinned down on the ends in order to allow a closer approach of the magnetic pole pieces, pass through the columns of brass b b_1 and are fastened in position by screws s_2 s_2. Springs r r_1 and collars c c_1 are slipped on the rods, the latter serving to set the points of the rods at a certain suitable distance by means of screws s_3 s_3, and the former to draw the points apart. When it is desired to start the arc, one of the hard rubber handles h h_1 is tapped quickly with the hand, whereby the points of the rods are brought in contact, but are instantly separated by the springs r r_1. Such an arrangement has been found to be often necessary, namely in cases when the E. M. F. was not large enough to cause the discharge to break through the gap, and also when it was desirable to avoid short circuiting of the generator by the metallic contact of the rods. The rapidity of the interruptions of the current with a magnet depends on the intensity of the magnetic field and on the potential difference at the ends of the arc. The interruptions are generally in such quick succession as to produce a musical sound. Years ago it was observed that when a powerful induction coil is discharged between the poles of a strong magnet the

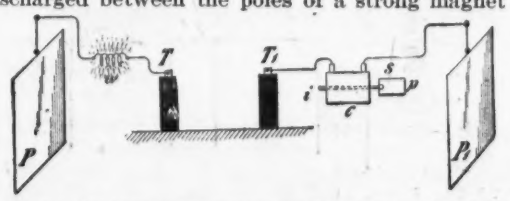


FIG. 11.—SHOWING EFFECTS OF CURRENTS FLOWING THROUGH OPEN CIRCUITS.

discharge produced a loud noise not unlike a small pistol shot. It was vaguely stated that the spark was intensified by the presence of the magnetic field. It is now clear that the discharge current, flowing for some time, was interrupted a great number of times by the magnet, thus producing the sound. The phenomenon is especially marked when the field circuit of a large magnet or dynamo is broken in a powerful magnetic field.

When the current through the gap is comparatively large, it is of advantage to slip on the points of the discharge rods pieces of very hard carbon and let the arc play between the carbon pieces. This preserves the rods and besides has the advantage of keeping the air space

hotter, as the heat is not conducted away as quickly through the carbons, and the result is that a smaller E. M. F. in the arc gap is required to maintain a succession of discharges.

Another form of discharger which may be employed with advantage in some cases is illustrated in Fig. 3. In this form the discharge rods d d_1 pass through perforations in a wooden box B, which is thickly coated with mica on the inside, as indicated by the heavy lines. The perforations are provided with mica tubes m m_1 of some thickness, which are preferably not in contact with the rods d d_1. The box has a cover C which is a little larger and descends on the outside of the box. The spark gap is warmed by a small lamp l contained in the box. A plate p above the lamp allows the draught to pass only through the chimney c of the lamp, the air entering through holes o o in or near the bottom of the box and following the path indicated by the arrows. When the discharger is in operation the door of the box is closed so that the light of the arc is not visible outside. It is desirable to exclude the light as perfectly as

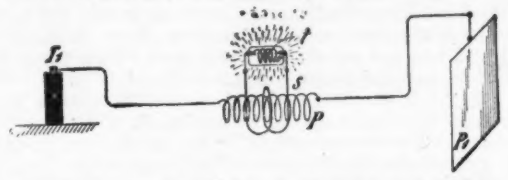


FIG. 12.—CONVERSION ON OPEN CIRCUIT WITH COIL AND INSULATED PLATE.

possible, as it interferes with some experiments. This form of discharger is simple and very effective when properly manipulated. The air being warmed to a certain temperature has its insulating power impaired, it becomes dielectrically weak, as it were, and the consequence is that the arc can be established at much greater distance. The air should, of course, be sufficiently insulating to allow the discharge to pass through the gap disruptively. The arc formed under such conditions, when long, may be made extremely sensitive, and the weak draught through the lamp chimney c is quite sufficient to produce rapid interruptions. The adjustment is made by regulating the temperature and velocity of the draught. Instead of using a lamp it answers the purpose to provide for a draught of warm air in other ways. A very simple way which has been practiced is to inclose the arc in a long vertical tube with plates on the top and bottom for regulating the temperature and velocity of the air current. Some provision had to be made for deadening the sound.

The air may be rendered dielectrically weak also by rarefaction. Dischargers of this kind have likewise been used by me in connection with the magnet. A large tube is for this purpose provided with heavy electrodes of carbon or metal, between which the discharge is made to pass, the tube being placed in a powerful magnetic field. The exhaustion of the tube is carried to a point at which the discharge breaks through easily, but the pressure should be more than 75 millimetres, at which the ordinary thread discharge occurs. In another form of discharger, combining the features before mentioned, the discharge was made to pass between two adjustable magnetic pole pieces, the space between them being kept at an elevated temperature.

It should be remarked here that when such, or interrupting devices of any kind, are used and the currents are passed through the primary of a disruptive discharge coil, it is not, as a rule, of advantage to produce a number of interruptions of the current per second greater than the natural frequency of vibration of the dynamo supply circuit, which is ordinarily small. It should also be pointed out here, that while the devices mentioned in connection with the disruptive discharge are advantageous under certain conditions, they may be sometimes a source of trouble, as they produce intermittences and other irregularities in the vibration which it would be very desirable to overcome.

There is, I regret to say, in this beautiful method of conversion a defect, which fortunately is not vital, and which I have been gradually overcoming. I will best call attention to this defect and indicate a fruitful line of work by comparing the electrical process with its mechanical analogue. The process may be illustrated in this manner. Imagine a tank with a wide opening at the bottom, which is kept closed by spring pressure, but so that it snaps off suddenly when the liquid in the tank has reached a certain height. Let the fluid be supplied to the tank by means of a pipe feeding at a certain rate. When the critical height of the liquid is reached, the spring gives way and the bottom of the tank drops out. Instantly the liquid falls through the wide opening, and the spring, reasserting itself, closes the bottom again. The tank is now filled, and after a certain time interval

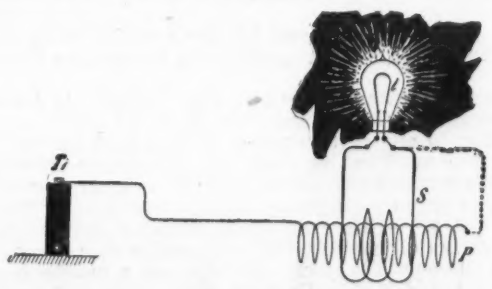


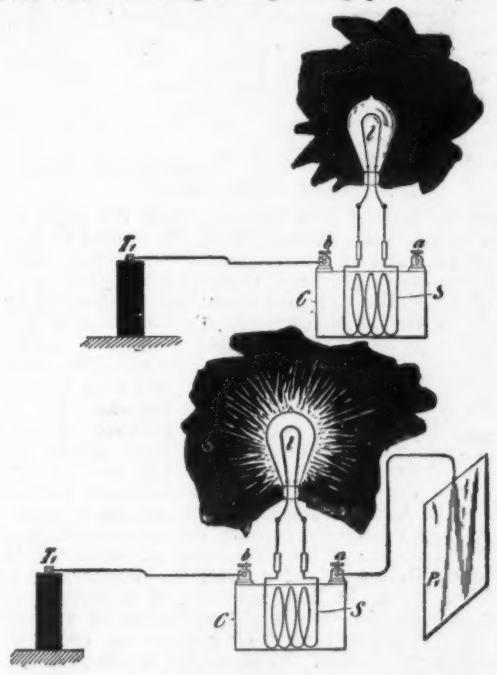
FIG. 13.—CONVERSION ON OPEN CIRCUIT WITH COIL ALONE.

the same process is repeated. It is clear, that if the pipe feeds the fluid quicker than the bottom outlet is capable of letting it pass through, the bottom will remain off and the tank will still overflow. If the rates of supply are exactly equal, then the bottom lid will remain partially open and no vibration of the same and of the liquid column will generally occur, though it might, if started by some means. But if the inlet pipe does not feed the fluid fast enough for the outlet, then there will be always vibration. Again, in such cases, each time the bottom flaps up or down the spring and the liquid column, if the pliability of the spring and the inertia of the moving parts are properly chosen, will perform independent vibrations. In this analogue the fluid may be likened to electricity or electrical energy, the tank to the condenser, the spring to the dielectric and the pipe to the conductor through which electricity is supplied to the condenser. To make this analogy quite complete it is necessary to make the assumption that the bottom, each time it gives way, is knocked violently against a non-elastic stop, this impact involving some loss of energy, and that, besides, some dissipation of energy results, due to frictional losses. In the preceding analogue the liquid is supposed to be under a steady pressure. If the pressure of the fluid be assumed to vary rhythmically, this may be taken as corresponding to the case of an alternating current. The process is then not quite as simple to consider, but the action is the same in principle.

It is desirable, in order to maintain the vibration economically, to reduce the impact and frictional losses as much as possible. As regards the latter, which in the electrical analogue correspond to the losses due to the resistance of the circuits, it is impossible to obviate them entirely, but they can be reduced to a minimum by a proper selection of the dimensions of the circuits and by the employment of thin conductors in the form of strands. But the loss of energy caused by the first breaking through of the dielectric—which in the above example corresponds to the violent knock of the bottom against the inelastic stop—would be more important to overcome. At the moment of the breaking through, the air space has a very high resistance, which is probably reduced to a very small value when the current has reached some strength, and the space is brought to a high temperature. It would materially diminish the loss of energy if the space were always kept at an extremely high temperature, but then there would be no disruptive break. By warming the space moderately by means of a lamp or otherwise the economy as far as the arc is concerned is sensibly increased. But the magnet or other interrupting device does not diminish the loss in the arc. Likewise, a jet of air only facilitates the carrying off of the energy. Air, or a gas in general, behaves curiously in this respect. When two bodies, charged to a very high potential, discharge disruptively through an air space, any amount of energy may be carried off by the air. This energy is evidently dissipated by bodily carriers, in impact and collisional losses of the molecules. The exchange of the molecules in the space occurs with inconceivable rapidity. A powerful discharge taking place between two electrodes, they may remain entirely cool, and yet the loss in the air may represent any amount of energy. It is perfectly practicable, with very great potential differences in the gap, to dissipate several horse power in the arc of the discharge without even noticing a small increase in the temperature of the electrodes. All the frictional losses occur then practically in the air. If the exchange of the air molecules is prevented, as by inclosing the air hermetically, the gas inside of the vessel is brought quickly to a high temperature, even with a very small discharge. It is difficult to estimate how much of the energy is lost in sound waves, audible or not, in a powerful discharge. When the currents through the gap are large, the electrodes may become rapidly heated, but this is not a reliable measure of the energy wasted in the arc, as the loss through the gap itself may be comparatively small. The air or a gas in general is, at ordinary pressures at least, clearly not the best medium through which a disruptive discharge should occur. Air or other gas under great pressure is of course a much more suitable medium for the discharge gap. I have carried on long-continued experiments in this direction, unfortunately less practicable on acount of the difficulties and expense in getting air under great pressure. But even if the medium in the discharge space is solid or liquid, still the same losses take place, though they are generally smaller, for just as soon as the arc is established the solid or liquid is volatilized. Indeed, there is no body known which would not be disintegrated by the arc, and it is an open question among scientific men whether an arc discharge could occur at all in the air itself without the particles of the electrodes being torn off. When the current through the gap is very small and the arc very long, I believe that a relatively considerable amount of heat is taken up in the disintegration of the electrodes, which partially on this account may remain quite cold.

The ideal medium for a discharge gap should only crack, and the ideal electrode should be of some material which cannot be disintegrated. With small currents through the gap it is best to employ aluminium, but not when the currents are large. The disruptive break in the air, or more or less in any ordinary medium, is not of the nature of a crack, but it is rather comparable to the piercing of innumerable bullets through a mass offering great frictional resistance to the motion of the bullets, this involving considerable loss of energy. A medium which would merely crack when strained electrostatically—and this possibly might be the case with a perfect vacuum, that is, pure ether—would involve a very small loss in the gap, so small as to be entirely negligible, at least theoretically, because a crack may be produced by an infinitely small displacement. In exhausting an oblong bulb provided with two aluminium terminals with the greatest care I have succeeded in producing such a vacuum that the secondary discharge of a disruptive discharge coil would break disruptively through the bulb in the form of fine spark streams. The curious point was that the discharge would completely ignore the terminals and start far behind the two aluminium plates which served as electrodes. This extraordinarily high vacuum could only be maintained for a very short while. To return to the ideal medium, think, for the sake of illustration, of a piece of glass or similar body clamped in a vise, and the latter lightened more and more. At a certain point a minute increase of the pressure will cause the glass to crack. The loss of energy involved in splitting the glass may be practically nothing, for though the force is great the displacement need be but extremely small. Now imagine that the glass would possess the property of closing again perfectly the crack upon a minute diminution of the pressure. This is the way the dielectric in the discharge space should behave. But inasmuch as there would be always some loss in the gap the medium which should be continuous should exchange through the gap at a rapid rate. In the preceding example, the glass being perfectly closed, it would mean that the dielectric in the discharge space possesses a great insulating power; the glass being cracked, it would signify that the medium in the space is a good conductor. The dielectric should vary enormously in resistance by minute variations of the E. M. F. across the discharge space. This condition is attained, but in an extremely imperfect manner, by warming the air space to a certain critical temperature, dependent on the E. M. F. across the gap, or by otherwise impairing the insulating power of the air. But as a matter of fact the air does never break down disruptively, if this term be rigorously interpreted, for before the sudden rush of the current occurs, there is always a weak current preceding it, which rises first gradually and then with comparative suddenness. That is the reason why the rate of change is very much greater when glass, for instance, is broken through, than when the break takes place through an air space of equivalent dielectric strength. As a medium for the discharge space a solid, or even a liquid would be preferable therefore. It is somewhat difficult to conceive of a solid body which would possess the property of closing instantly after it has been cracked. But a liquid, especially under great pressure, behaves practically like a solid, while it possesses the property of closing the crack. Hence it was thought that a liquid insulator might be more suitable as a dielectric than air. Following out this idea, a number of different forms of dischargers, in which a variety of such insulators, sometimes under great pressure, were employed, have been experimented upon. It is thought sufficient to dwell in a few words upon one of the forms experimented upon. One of these dischargers is illustrated in Figs. 4a and 4b.

A hollow metal pulley P (Fig. 4a), was fastened upon an arbor a, which by suitable means was rotated at a considerable speed. In the inside of the pulley, but disconnected from the same, was supported a thin disc h_1 (which is shown thick for the sake of clearness), of hard rubber, in which there were embedded two metal segments s s with metallic extensions e e into which were screwed conducting terminals t t covered with thick tubes of hard rubber t t. The rubber disc h, with its metallic segments S S, was finished in a lathe, and its entire surface highly polished so as to offer the smallest possible frictional resistance to the motion through a fluid. In the hollow of the pulley an insulating liquid such as a thin oil was poured so as to reach very nearly to the opening left in the flange f, which was screwed tightly on the front side of the pulley. The terminals t t were connected to the opposite coatings of a battery of condensers so that the discharge occurred through the liquid. When the pulley was rotated the liquid was forced against the rim of the pulley and considerable fluid pressure resulted. In this simple way the discharge gap was filled with a medium which behaved practically like a solid, which possessed the quality of closing instantly upon the occurrence of the break, and which moreover was circulating through the gap at a rapid rate.



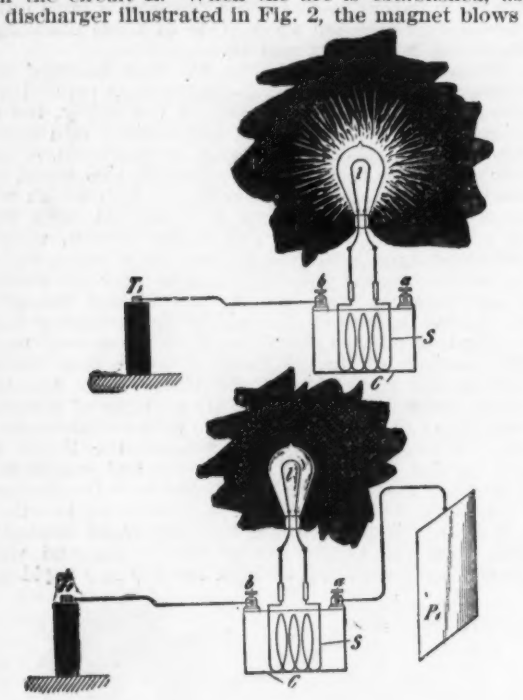
FIGS. 14a AND 14b.—EFFECT OF ATTACHED PLATE WITH LOW FREQUENCIES.

Very powerful effects were produced by dischargers of this kind with liquid interrupters, of which a number of different forms were made. It was found that, as expected, a longer spark for a given length of wire was obtainable in this way than by using air as an interrupting device. Generally the speed, and therefore also the fluid pressure, was limited by reason of the fluid friction, in the form of discharger described, but the practically obtainable speed was more than sufficient to produce a number of breaks suitable for the circuits ordinarily used. In some instances the metal pulley P was provided with a few projections inwardly, and a definite number of breaks was then produced which could be computed from the speed of rotation of the pulley. Experiments were also carried on with liquids of different insulating power with the view of reducing the loss in the arc. When an insulating liquid is moderately warmed the loss in the arc is diminished.

A point of some importance was noted in experiments with various discharges of this kind. It was found, for instance, that whereas the conditions maintained in these forms were favorable for the production of a great spark length, the currents so obtained were not best suited to the production of light effects. Experience undoubtedly has shown that for such purposes a harmonic rise and fall of the potential is preferable. Be it that a solid is rendered incandescent, or phosphorescent, or be it that energy is transmitted by condenser coating through the glass, it is quite certain that a harmonically rising and falling potential produces less destructive action, and that the vacuum is more permanently maintained. This would be easily explained if it were ascertained that the process going on in an exhausted vessel is of an electrolytic nature.

In the diagrammatical sketch, Fig. 1, which has been already referred to, the cases which are most likely to be met with in practice are illustrated. One has at his disposal either direct or alternating currents from a supply station. It is convenient for an experimenter in an isolated laboratory to employ a machine G, such as illustrated, capable of giving both kinds of currents. In such case it is also preferable to use a machine with multiple circuits, as in many experiments it is useful and convenient to have at one's disposal currents of different phases. In the sketch, D represents the direct and A the alternating current. In each of these, three branch circuits are shown, all of which are provided with double lines switches s s s s s s. Consider first the direct cur-

rent conversion; 1a represents the simplest case. If the E. M. F. of the generator is sufficient to break through a small air space, at least when the latter is warmed or otherwise rendered poorly insulating, there is no difficulty in maintaining a vibration with fair economy by judicious adjustment of the capacity, self-induction and resistance of the circuit L containing the devices l l m. The magnet N S can be in this case advantageously combined with the air space. The discharger d d with the magnet may be placed either way, as indicated by the full or by the dotted lines. The circuit 1a with the connections and devices is supposed to possess dimensions such as are suitable for the maintenance of a vibration. But usually the E. M. F. on the circuit or branch 1a will be something like 100 volts or so, and in this case it is not sufficient to break through the gap. Many different means may be used to remedy this by raising the E. M. F. across the gap. The simplest is probably to insert a large self-induction coil in series with the circuit L. When the arc is established, as by the discharger illustrated in Fig. 2, the magnet blows the



Figs. 15a and 15b.—Effect of Attached Plate with High Frequencies.

arc out the instant it is formed. Now the extra current of the break, being of high E. M. F., breaks through the gap, and a path of low resistance for the dynamo current being again provided, there is a sudden rush of the current from the dynamo upon the weakening or subsidence of the extra current. This process is repeated in rapid succession, and in this manner I have maintained oscillation with as low as 50 volts, or even less, across the gap. But conversion on this plan is not to be recommended on account of the too heavy currents through the gap and consequent heating of the electrodes; besides, the frequencies obtained in this way are low, owing to the high self-induction necessarily associated with the circuit. It is very desirable to have the E. M. F. as high as possible, first, in order to increase the economy of the conversion, and, secondly, to obtain high frequencies. The difference of potential in this electric oscillation is, of course, the equivalent of the stretching force in the mechanical vibration of the spring. To obtain very rapid vibration in a circuit of some inertia a great stretching force or difference of potential is necessary. Incidentally, when the E. M. F. is very great, the condenser which is usually employed in connection with the circuit need have but a small capacity, and many other advantages are gained. With a view of raising the E. M. F. to a many times greater value than obtainable from ordinary distribution circuits a rotating transformer g is used, as indicated in Fig. 2a, or else a separate high potential machine is driven by means of a motor operated from the generator G. The latter plan is in fact preferable, as changes are easier made. The connections from the high tension winding are quite similar to those in branch 1a with the exception that a condenser C, which should be adjustable, is connected to the high tension circuit. Usually, also, an adjustable self-induction coil in series with the circuit has been employed in these experiments. When the tension of the currents is very high the magnet ordinarily used in connection with the discharger is of comparatively small value, as it is quite easy to adjust the dimensions of the circuit so that oscillation is maintained. The employment of a steady E. M. F. in the high frequency conversion affords some advantages over the employment of alternating E. M. F., as the adjustments are much simpler and the action can be easier controlled. But unfortunately one is limited by the obtainable potential difference. The windings also break down easily in consequence of the sparks which form between the sections of the armature or commutator when a vigorous oscillation takes place. Besides, these transformers are expensive to build. It has been found by experience that it is best to follow the plan illustrated in Fig. 3a. In this arrangement a rotating transformer g is employed to convert the low tension direct currents into low frequency alternating currents, preferably also of small tension. The tension of the currents is then raised in a stationary transformer T. The secondary S of this transformer is connected to an adjustable condenser C which discharges through the gap or discharger d d, placed in either of the ways indicated, through the primary P of a disruptive discharge coil, the high frequency currents being obtained from the secondary S of this coil, as described on previous occasions. This will undoubtedly be found the cheapest and most convenient way of converting direct currents.

The three branches of the circuit A represent the usual cases met in practice when alternating currents are converted. In Fig. 1b a condenser C, generally of large capacity, is connected to the circuit L containing the devices l l, m m. The devices m m are supposed to be of high self-induction so as to bring the frequency of the circuit more or less to that of the dynamo. In this instance the discharger d d should best have a number of makes and breaks per second equal to twice the frequency of the dynamo. If not so, then it should have at least a number equal to a multiple or even fraction of the dynamo frequency. It should be observed, referring to 1b, that the conversion to a high potential is also effected when the discharger d d, which is shown in the sketch, is omitted. But the effects which are produced by currents which rise instantly to high values, as in a disruptive discharge, are entirely different from those produced by dynamo currents which rise and fall harmonically. So, for instance, there might be in a given case a number of makes and breaks at d d equal to just twice the frequency of the dynamo, or, in other words, there may be the same number of fundamental oscillations as would be produced without the discharge gap, and there might even not be any quicker superimposed vibration; yet the differences of potential at the various points of the circuit, the impedance and other phenomena, dependent upon the rate of change, will bear no similarity in the two cases. Thus, when working with currents discharging disruptively, the element chiefly to be considered is not the frequency, as a student might be apt to believe, but the rate of change per unit of time. With low frequencies in a certain measure the same effects may be obtained as with high frequencies, provided the rate of change is sufficiently great. So if a low frequency current is raised to a potential of say 75,000 volts, and the high tension current passed through a series of high resistance lamp filaments, the importance of the rarefied gas surrounding the filament is clearly noted, as will be seen later; or, if a low frequency current of several thousand amperes is passed through a metal bar, striking phenomena of impedance are observed, just as with currents of high frequencies. But it is, of course, evident that with low frequency currents it is impossible to obtain such rates of change per unit of time as with high frequencies, hence the effects produced by the latter are much more prominent. It was deemed advisable to make the preceding remarks, inasmuch as many more recently described effects have been unwittingly identified with high frequencies. Frequency alone in reality does not mean anything, except when an undisturbed harmonic oscillation is considered.

In the branch 3b a similar disposition as in 1b is illustrated, with the difference that the currents discharging through the gap d d are used to induce currents in the secondary S of a transformer T. In such case the secondary should be provided with an adjustable condenser for the purpose of tuning it to the primary.

Fig. 2b illustrates a plan of alternate current high frequency conversion, which is most frequently used, and which is found to be most convenient. This plan has been dwelt upon in detail on previous occasions, and need not be described here.

Some of these results were obtained by the use of a high frequency alternator. A description of such machines will be found in my original paper before the American Institute of Electrical Engineers, and in periodicals of that period, notably in the "Electrical Engineer" of March 18, 1891.

I will now proceed with the experiments.

On Phenomena Produced by Electrostatic Force.

The first class of effects I intend to show you are effects produced by electrostatic force. It is the force which governs the motion of the atoms, which causes them to collide and develop the life-sustaining energy of heat and light, and which causes them to aggregate in an infinite variety of ways, according to Nature's fanciful designs, and to form all these wondrous structures we perceive around us; it is, in fact, if our present views be true, the most important force for us to consider in Nature. As the term electrostatic might imply a steady electric condition, it should be remarked that in these experiments the force is not constant, but varies at a rate which may be considered moderate, about one million times a second, or thereabouts. This enables me to produce many effects which are not producible with an unvarying force.

When two conducting bodies are insulated and electrified, we say that an electrostatic force is acting between

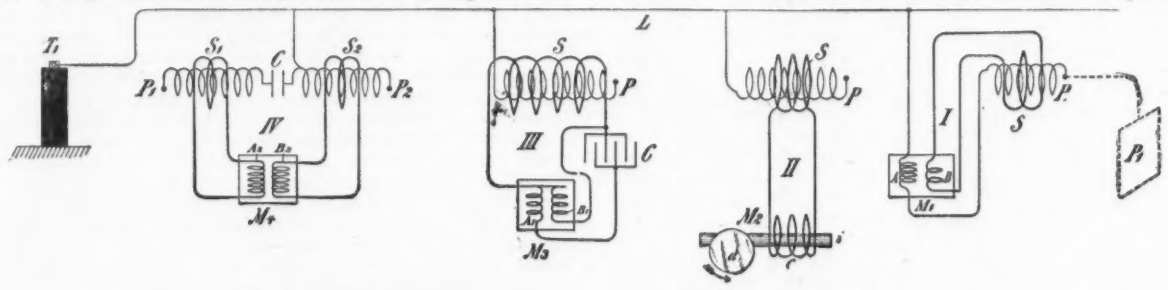


Fig. 16.—Ways of Operating Motors with Only One Lead.

them. This force manifests itself in attractions, repulsions and stresses in the bodies and space or medium without. So great may be the strain exerted in the air, or whatever separates the two conducting bodies, that it may break down, and we observe sparks or bundles of light or streamers, as they are called. These streamers form abundantly when the force through the air is rapidly varying. I will illustrate this action of electrostatic force in a novel experiment in which I will employ the induction coil before referred to. The coil is contained in a trough filled with oil, and placed under the table. The two ends of the secondary wire pass through the two thick columns of hard rubber, which protrude to some height above the table. It is necessary to insulate the ends or terminals of the secondary heavily with hard rubber, because even dry wood is by far too poor an insulator for these currents of enormous potential differences. On one of the terminals of the coil I have placed a large sphere of sheet brass, which is connected to a larger insulated brass plate, in order to enable me to perform the experiments under conditions which, as you will see, are more suitable for this experiment. I now set the coil to work and approach the free terminal with a metallic object held in my hand, this simply to avoid burns. As I approach the metallic object to a distance of eight or ten inches, a torrent of furious sparks breaks forth from the end of the secondary wire, which passes through the rubber column. The sparks cease when the metal in my hand touches the wire. My arm is now traversed by a powerful electric current, vibrating at about the rate of one million times a second. All around me the electrostatic force makes itself felt, and the air molecules and particles of dust flying about are acted upon and hammering violently against my body. So great is this agitation of the particles, that when the lights are turned out you may see streams of feeble light appear on some parts of my body. When such a streamer breaks out on any part of the body it produces a sensation like the pricking of a needle. Were the potentials sufficiently high and the frequency of the vibration rather low, the skin would probably be ruptured under the tremendous strain, and the blood would rush out with great force in the form of fine spray or jet so thin as to be invisible, just as oil will when placed on the positive terminal of a Holtz machine. This breaking through of the skin, though it may seem impossible at first, would perhaps occur by reason of the tissues under the skin being incomparably better conducting. This, at least, appears plausible, judging from some observations.

I can make these streams of light visible to all, by touching with the metallic object one of the terminals as before, and approaching my free hand to the brass sphere, which is connected to the second terminal of the coil. As the hand is approached the air between it and the sphere, or in the immediate neighborhood, is more violently agitated and you see streams of light now break forth from my finger tips and from the whole hand (Fig. 5). Were I to approach the hand closer, powerful sparks would jump from the brass sphere to my hand, which might be injurious. The streamers offer no particular inconvenience, except that in the ends of the finger tips a burning sensation is felt. They should not be confounded with those produced by an influence machine, because in many respects they behave differently. I have attached the brass sphere and plate to one of the terminals in order to prevent the formation of visible streamers on that terminal, also in order to prevent sparks from jumping at a considerable distance. Besides, the attachment is favorable for the working of the coil.

The streams of light which you have observed issuing from my hand are due to a potential of about 200,000 volts, alternating in rather irregular intervals, something like a million times a second. A vibration of the same amplitude, but four times as fast, to maintain which over 3,000,000 volts would be required, would be more than sufficient to envelop my body in a complete sheet of flame. But this flame would not burn me up; quite contrarily, the probability is that I would not be injured in the least. Yet a hundredth part of that energy, otherwise directed, would be amply sufficient to kill a person.

The amount of energy which may thus be passed into the body of a person depends on the frequency and potential of the currents, and by making both of these very great, a vast amount of energy may be passed into the body without causing any discomfort, except, perhaps, in the arm, which is traversed by a true conduction current. The reason why no pain in the body is felt, and no injurious effect noted, is that everywhere, if a current be imagined to flow through the body, the direction of its flow would be at right angles to the surface; hence the body of the experimenter offers an enormous section to the current, and the density is very small, with the exception of the arm, perhaps, where the density may be considerable. But if only a small fraction of that energy would be applied in such a way that a current would traverse the body in the same manner as a low frequency current, a shock would be received which might be fatal. A direct or low frequency alternating current is fatal, I think, principally because its distribution through the body is not uniform, as it must divide itself in minute streamlets of great density, whereby some organs are vitally injured. That such a process occurs I have not the least doubt, though no evidence might apparently exist or be found upon examination. The surest to injure and destroy life is a continuous current, but the most painful is an alternating current of very low frequency. The expression of these views, which are the result of long-continued experiment and observation, both with steady and varying currents, is elicited by the interest which is at present taken in this subject, and by the manifestly erroneous ideas which are daily propounded in journals on this subject.

I may illustrate an effect of the electrostatic force by another striking experiment, but, before, I must call your attention to one or two facts. I have said before, that when the medium between two oppositely electrified bodies is strained beyond a certain limit it gives way and, stated in popular language, the opposite electric charges unite and neutralize each other. This breaking down of the medium occurs principally when the force acting between the bodies is steady, or varies at a moderate rate. Were the variation sufficiently rapid such a destructive break would not occur, no matter how great the force, for all the energy would be spent in radiation, convection and mechanical and chemical action. Thus the spark length, or greatest distance through which a spark will jump between the electrified bodies, is the smaller the greater the variation or time rate of change. But this rule may be taken to be true only in a general way, when comparing rates which are widely different.

I will show you by an experiment the difference in the effect produced by a rapidly varying and a steady or moderately varying force. I have here two large circular brass plates p p (Fig. 6a and Fig. 6b), supported on movable insulating stands on the table, connected to the ends of the secondary of a similar coil as the one used before, I place the plates 10 or 12 inches apart, and set the coil to work. You see the whole space between the plates, nearly two cubic feet, filled with uniform light, Fig. 6a. This light is due to the streamers you have seen

in the first experiment, which are now much more intense. I have already pointed out the importance of these streamers in commercial apparatus and their still greater importance in some purely scientific investigations. Often they are too weak to be visible, but they always exist, consuming energy and modifying the action of the apparatus. When intense, as they are at present, they produce ozone in great quantity, and also, as Prof. Crookes has pointed out, nitrous acid. So quick is the chemical action that if a coil such as this one is worked for a very long time, it wil make the atmosphere of a small room unbearable, for the eyes and throat are attacked. But when moderately produced the streamers refresh the atmosphere wonderfully, like a thunderstorm, and exercise unquestionably a beneficial effect.

In this experiment the force acting between the plates changes in intensity and direction at a very rapid rate. I will now make the rate of change per unit time much smaller. This I effect by rendering the discharges through the primary of the induction coil less frequent, and also by diminishing the rapidity of the vibration in the secondary. The former result is conveniently secured by lowering the E. M. F. over the air gap in the primary circuit, the latter, by approaching the two brass plates to a distance of about three or four inches. When the coil is set to work you see no streamers or light between the plates, yet the medium between them is under a tremendous strain. I still further augment the strain by raising the E. M. F. in the primary circuit, and soon you see the air give way and the hall is illuminated by a shower of brilliant and noisy sparks, Fig. 6b. These sparks could be produced also with unvarying force; they have been for many years a familiar phenomenon, though they were usually obtained from entirely different apparatus. In describing these two phenomena, so radically different in appearance, I have advisedly spoken of a "force" acting between the plates. It would be in accordance with accepted views to say that there was an "alternating E. M. F." acting between the plates. This term is quite proper and applicable in all cases where there is evidence of at least a possibility of an essential interdependence of the electric state of the plates, or electric action in their neighborhood. But if the plates were removed to an infinite distance, or if at a finite distance, there is no probability or necessity whatever for such dependence. I prefer to us the term "electrostatic force," and to say that such a force is acting around each plate or electrified insulated body in general. There is an inconvenience in using this expression, as the term incidentally means a steady electric condition; but a proper nomenclature will eventually settle this difficulty.

I now return to the experiment to which I have already alluded, and with which I desire to illustrate a striking effect produced by a rapidly varying electrostatic force. I attach to the end of the wire, l (Fig. 7), which is in connection with one of the terminals of the secondary of the induction coil, an exhausted bulb b. This bulb contains a thin carbon filament f, which is fastened to a platinum wire w, sealed in the glass and leading outside of the bulb, where it connects to the wire l. The bulb may be exhausted to any degree attainable with ordinary apparatus. Just a moment before, you have witnessed the breaking down of the air between the charged brass plates. You know that a plate of glass, or any other insulating material, would break down in like manner. Had I, therefore, a metallic coating attached to the outside of the bulb, or placed near the same, and were this coating connected to the other terminal of the coil, you would be prepared to see the glass give way if the strain were sufficiently increased. Even were the coating not connected to the other terminal, but to an insulated plate, still, if you have followed recent developments, you would naturally expect a rupture of the glass.

But it will certainly surprise you to note that under the action of the varying electrostatic force the glass gives way when all other bodies are removed from the bulb. In fact, all the surrounding bodies we perceive might be removed to an infinite distance without affecting the result in the slightest. When the coil is set to work, the glass is invariably broken through at the seal, or other narrow channel, and the vacuum is quickly impaired. Such a damaging break would not occur with a steady force, even if the same were many times greater. The break is due to the agitation of the molecules of the gas within the bulb, and outside of the same. This agitation, which is generally most violent in the narrow pointed channel near the seal, causes a heating and rupture of the glass. This rupture, would, however, not occur, not even with a varying force, if the medium filling the inside of the bulb and that surrounding it were perfectly homogeneous. The break occurs much quicker if the top of the bulb is drawn out into a fine fibre. In bulbs used with these coils such narrow, pointed channels must therefore be avoided.

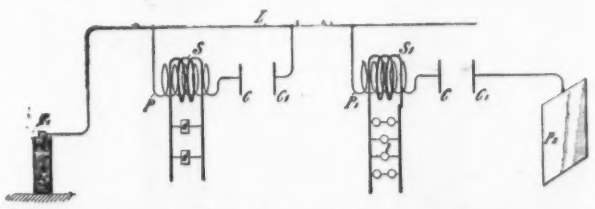


FIG. 17.—SINGLE WIRE CONVERSION AND DISTRIBUTION, WITH SIMPLE MEANS FOR REGULATING THE EFFECTS.

When a conducting body is immersed in air, or similar insulating medium, consisting of, or containing, small freely movable particles capable of being electrified, and when the electrification of the body is made to undergo a very rapid change—which is equivalent to saying that the electrostatic force acting around the body is varying in intensity—the small particles are attracted and repelled, and their violent impacts against the body may cause a mechanical motion of the latter. Phenomena of this kind are noteworthy, inasmuch as they have not been observed before with apparatus such as has been commonly in use. If a very light conducting sphere be suspended on an exceedingly fine wire, and charged to a steady potential, however high, the sphere will remain at rest. Even if the potential would be rapidly varying, provided that the small particles of matter, molecules or atoms, are evenly distributed, no motion of the sphere should result. But if one side of the conducting sphere is covered with a thick insulating layer, the impacts of the particles will cause the sphere to move about, generally in irregular curves, Fig. 8a. In like manner, as I have shown on a previous occasion, a fan of metal sheet, Fig. 8b, covered partially with insulating material as indicated, and placed upon the terminal of the coil so as to turn freely in it, is spun around.

All these phenomena you have witnessed, and others, which will be shown later, are due to the presence of a medium like air, and would not occur in a continuous medium. The action of the air may be illustrated still better by the following experiment: I take a glass tube t, Fig. 9, of about an inch in diameter, which has a platinum wire w sealed in the lower end, and to which is attached a thin lamp filament f. I connect the wire with the terminal of the coil and set the coil to work. The platinum wire is now electrified positively and negatively in rapid succession, and the wire and air inside of the tube are rapidly heated by the impacts of the particles, which may be so violent as to render the filament incandescent. But if I pour oil in the tube, just as soon as

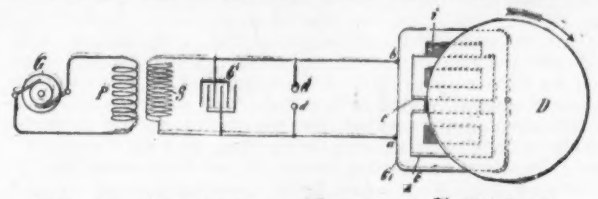


FIG. 18.—OPERATING A MOTOR BY DISRUPTIVE DISCHARGES.

the wire is covered with the oil, all action apparently ceases and there is no marked evidence of heating. The reason of this is that the oil is a practically continuous medium. The displacements in such a continuous medium are, with these frequencies, to all appearance incomparably smaller than in air, hence the work performed in such a medium is insignificant. But oil would behave very differently with frequencies many times as great, for even though the displacements be small, if the frequency were much greater, considerable work might be performed in the oil.

The electrostatic attractions and repulsions between bodies of measurable dimensions are, of all the manifestations of this force, the first so-called electrical phenomena noted. But though they have been known to us for many centuries, the precise nature of the mechanism concerned in these actions is still unknown to us, and has not been even quite satisfactorily explained. What kind of mechanism must that be? We cannot help wondering when we observe two magnets attracting and repelling each other with a force of hundreds of pounds with apparently nothing between them. We have in our commercial dynamos magnets capable of sustaining in mid-air tons of weight. But what are even these forces acting between magnets when compared with the tremendous attractions and repulsions produced by electrostatic force, to which there is apparently no limit as to intensity. In lightning discharges bodies are often charged to so high a potential that they are thrown away with inconceivable force and torn asunder or shattered into fragments. Still even such effects cannot compare with the attractions and repulsions which exist between charged molecules or atoms, and which are sufficient to project them with speeds of many kilometres a second, so that under their violent impact bodies are rendered highly incandescent and are volatilized. It is of special interest for the thinker who inquires into the nature of these forces to note, that whereas the actions between individual molecules or atoms occur seemingly under any condition, the attractions and repulsions of bodies of measurable dimensions imply a medium possessing insulating properties. So, if air, either by being rarefied or heated, is rendered more or less conducting, these actions between two electrified bodies practically cease, while the actions between the individual atoms continue to manifest themselves.

An experiment may serve as an illustration and as a means of bringing out other features of interest. Some time ago I showed that a lamp filament or wire mounted in a bulb and connected to one of the terminals of a high tension secondary coil is set spinning, the top of the filament generally describing a circle. This vibration was very energetic when the air in the bulb was at ordinary pressure, and became less energetic when the air in the bulb was strongly compressed. It ceased altogether when the air was exhausted, so as to become comparatively good conducting. I found at that time that no vibration took place when the bulb was very highly exhausted. But I conjectured that the vibration which I ascribed to the electrostatic action between the walls of the bulb and the filament should take place also in a highly exhausted bulb. To test this under conditions which were more favorable, a bulb like the one in Fig. 10 was constructed. It comprised a globe b, in the neck of which was sealed a platinum wire w carrying a thin lamp filament f. In the lower part of the globe a tube t was sealed so as to surround the filament. The exhaustion was carried as far as it was practicable with the apparatus employed.

This bulb verified my expectation, for the filament was set spinning when the current was turned on, and became incandescent. It also showed another interesting feature, bearing upon the preceding remarks, namely, when the filament had been kept incandescent some time, the narrow tube and the space inside were brought to an elevated temperature, and as the gas in the tube then became conducting the electrostatic attraction between the glass and the filament became very weak or ceased, and the filament came to rest. When it came to rest it would glow far more intensely. This was probably due to its assuming the position in the centre of the tube where the molecular bombardment was most intense, and also partly to the fact that the individual impacts were more violent and that no part of the supplied energy was converted into mechanical movement. Since, in accordance with accepted views, in this experiment the incandescence must be attributed to the impacts of the particles, molecules or atoms in the heated space, these particles must, therefore, in order to explain such action, be assumed to behave as independent carriers of electric charges immersed in an insulating medium; yet there is no attractive force between the glass tube and the filament because the space in the tube is, as a whole, conducting.

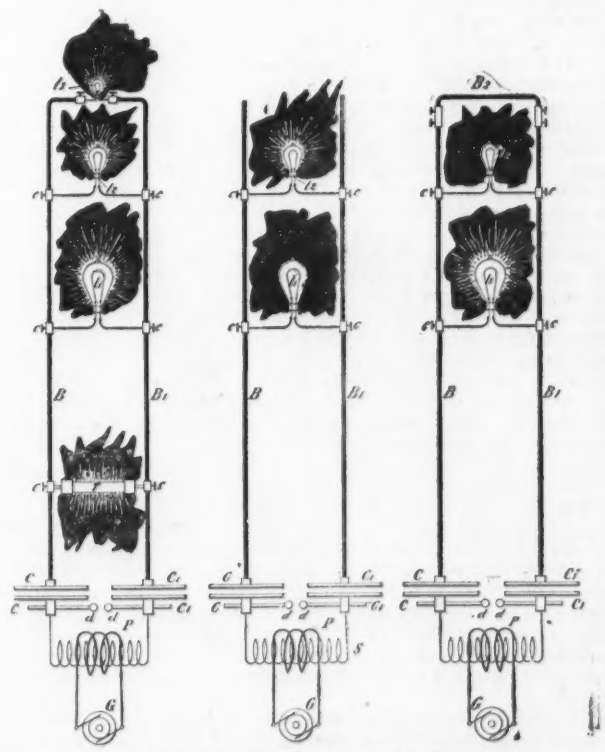
It is of some interest to observe in this connection that whereas the attraction between two electrified bodies may cease owing to the impairing of the insulating power of the medium in which they are immersed, the repulsion between the bodies may still be observed. This may be explained in a plausible way. When the bodies are placed at some distance in a poorly conducting medium, such as slightly warmed or rarefied air, and are suddenly electrified, opposite electric charges being imparted to them, these charges equalize more or less by leakage through the air. But if the bodies are similarly electrified, there is less opportunity afforded for such dissipation, hence the repulsion observed in such case is greater than the attraction. Repulsive actions in a gaseous medium are, however, as Prof. Crookes has shown, enhanced by molecular bombardment.

ON CURRENT OR DYNAMIC ELECTRICITY PHENOMENA.

So far, I have considered principally effects produced by a varying electrostatic force in an insulating medium, such as air. When such a force is acting upon a conducting body of measurable dimensions, it causes within the same, or on its surface, displacements of the electricity and gives rise to electric currents, and these produce another kind of phenomena, some of which I shall presently endeavor to illustrate. In presenting this second class of electrical effects, I will avail myself principally of such as are producible without any return circuit, hoping to interest you the more by presenting these phenomena in a more or less novel aspect.

It has been for a long time customary, owing to the limited experience with vibratory currents, to consider an electric current as something circulating in a closed conducting path. It was astonishing at first to realize that a current may flow through the conducting path even if the latter be interrupted, and it was still more surprising to learn that sometimes it may be even easier to make a current flow under such conditions than through a closed path. But that old idea is gradually disappearing, even among practical men, and will soon be entirely forgotten.

If I connect an insulated metal plate P, Fig. 11, to one of the terminals T of the induction coil by means of a wire, though this plate be very well insulated, a current passes through the wire when the coil is set to work. First I wish to give you evidence that there is a current passing through the connecting wire. An obvious way of demonstrating this is to insert between the terminal of the coil and the insulated plate a very thin platinum or German silver wire w and bring the latter to incandescence or fusion by the current. This requires a rather large plate or else current impulses of very high potential and frequency. Another way is to take a coil C, Fig. 11, containing many turns of thin insulated wire, and to insert the same in the path of the current to the plate. When I connect one of the ends of the coil to the wire leading to another insulated plate P, and its other end to the terminal T_1 of the induction coil, and set the latter to work, a current passes through the inserted coil C and the existence of the current may be made manifest in various ways. For instance, I insert an iron core i within the coil. The current being one of very high frequency, if it be of some strength, will soon bring the iron core to a noticeably higher temperature, as the hysteresis and current losses are great with such high frequencies. One might take a core of some size, laminated or not, it would matter little; but ordinary iron wire 1-16 or 1-8 of an inch thick is suitable for the purpose. While the induction coil is working, a current traverses the inserted coil, and only a few moments are sufficient to bring the iron wire i to an elevated temperature sufficient to soften the sealing-wax s, and cause a paper washer p, fastened by it to the iron wire to fall off. But with the apparatus such as I have here, other, much



FIGS. 19a, 19b AND 19c.—IMPEDANCE PHENOMENA.

more interesting, demonstrations of this kind can be made. I have a secondary S, Fig. 12, of coarse wire, wound upon a coil similar to the first. In the preceding experiment the current through the coil C, Fig. 11, was very small, but there being many turns a strong heating effect was, nevertheless, produced in the iron wire. Had I passed that current through a conductor in order to show the heating of the latter, the current might have been too small to produce the effect desired. But with this coil provided with a secondary winding I can now transform the feeble current of high tension which passes through the primary P into a strong secondary current of low tension, and this current will quite certainly do what I expect. In a small glass tube (t, Fig. 12) I have inclosed a coiled platinum wire, w, this merely in order to protect the wire. On each end of the glass tube is sealed a terminal of stout wire to which one of the ends of the platinum wire, w, is connected. I join the terminals of the secondary coil to these terminals and insert the primary p, between the insulated plate P_1 and the terminal T_1 of the induction coil as before. The latter being set to work, instantly the platinum wire w

is rendered incandescent, and can be fused even if it be very thick.

Instead of the platinum wire I now take an ordinary 50-volt 16-c. p. lamp. When I set the induction coil in operation the lamp filament is brought to high incandescence. It is, however, not necessary to use the insulated plate, for the lamp (l, Fig. 13) is rendered incandescent even if the plate P1 be disconnected. The secondary may also be connected to the primary as indicated by the dotted line in Fig. 13, to do away more or less with the electrostatic induction or to modify the action otherwise.

I may here call attention to a number of interesting observations with the lamp. First, I disconnect one of the terminals of the lamp from the secondary S. When the induction coil plays, a glow is noted which fills the whole bulb. This glow is due to electrostatic induction.

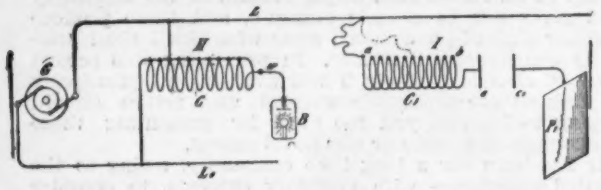


Fig. 20.—Plan Followed in Observing the Effects of Resonance.

It increases when the bulb is grasped with the hand, and the capacity of the experimenter's body thus added to the secondary circuit. The secondary, in effect, is equivalent to a metallic coating, which would be placed near the primary. If the secondary, or its equivalent, the coating, were placed symmetrically to the primary, the electrostatic induction would be nil under ordinary conditions, that is, when a primary return circuit is used, as both halves would neutralize each other. The secondary is, in fact, placed symmetrically to the primary, but the action of both halves of the latter, when only one of its ends is connected to the induction coil, is not exactly equal; hence, electrostatic induction takes place, and hence the glow in the bulb. I can nearly equalize the action of both halves of the primary by connecting the other free end of the same to the insulated plate, as in the preceding experiment. When the plate is connected, the glow disappears. With a smaller plate it would not entirely disappear, and then it would contribute to the brightness of the filament when the secondary is closed, by warming the air in the bulb.

To demonstrate another interesting feature, I have adjusted the coils used in a certain way. I first connect both the terminals of the lamp to the secondary, one end of the primary being connected to the terminal T_1 of the induction coil, and the other to the insulated plate P_1 as before. When the current is turned on, the lamp glows brightly, as shown in Fig. 14b, in which C is a fine wire coil and S a coarse wire secondary wound upon it. If the insulated plate P_1 is disconnected, leaving one of the ends a of the primary insulated, the filament becomes dark or generally it diminishes in brightness (Fig. 14a). Connecting, again, the plate P_1 and raising the frequency of the current, I make the filament quite dark or barely red, Fig. 15b. Once more I will disconnect the plate. One will, of course, infer that when the plate is disconnected, the current through the primary will be weakened, that therefore the E. M. F. will fall in the secondary S, and that the brightness of the lamp will diminish. This might be the case, and the result can be secured by an easy adjustment of the coils; also by varying the frequency and potential of the currents. But it is perhaps of greater interest to note that the lamp increases in brightness when the plate is disconnected (Fig. 15a). In this case all the energy the primary receives is now sunk into it, like the charge of a battery into an ocean cable, but most of that energy is recovered through the secondary and used to light the lamp. The current traversing the primary is strongest at the end b, which is connected to the terminal T_1 of the induction coil, and diminishes in strength towards the remote end a. But the dynamic inductive effect exerted upon the secondary S is now greater than before when the suspended plate was connected to the primary. These results might have been produced by a number of causes. For instance, the plate P_1 being connected, the reaction from the coil C may be such as to diminish the potential at the terminal T_1 of the induction coil, and therefore weaken the current through the primary of the coil C. Or the disconnecting of the plate may diminish the capacity effect with relation to the primary of the latter coil to such an extent that the current through it is diminished, though the potential at the terminal T_1 of the induction coil may be the same or even higher. Or the result might have been produced by the change of phase of the primary and secondary currents and consequent reaction. But the chief determining factor is the relation of the self-induction and capacity of coil C and plate P_1, and the frequency of the currents. The greater brightness of the filament in Fig. 15a is, however, in part due to the heating of the rarefied gas in the lamp by electrostatic induction, which, as before remarked, is greater when the suspended plate is disconnected.

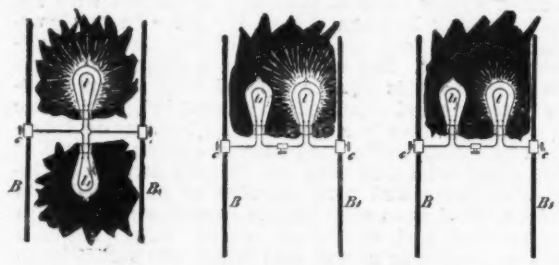
Still another feature of some interest I may here bring to your attention. When the insulated plate is disconnected and the secondary of the coil opened, by approaching a small object to the secondary, but very small sparks

Fig. 21.—Energy Transmission to Any Distance Without Wires.

can be drawn from it, showing that the electrostatic induction is small in this case. But upon the secondary being closed upon itself or through the lamp, the filament glowing brightly, strong sparks are obtained from the secondary. The electrostatic induction is now much greater, because the closed secondary determines a greater flow of current through the primary, and principally through that half of it which is connected to the induction coil. If now the bulb be grasped with the hand, the capacity of the secondary with reference to the primary is augmented by the experimenter's body and the luminosity of the filament is increased, the incandescence now being due partly to the flow of current through the filament and partly to the molecular bombardment of the rarefied gas in the bulb.

The preceding experiments will have prepared one for the next following results of interest, obtained in the course of these investigations. Since I can pass a current through an insulated wire merely by connecting one of its ends to the source of electrical energy, since I can induce by it another current, magnetize an iron core, and, in short, perform all operations, as though a return circuit were used, clearly I can also drive a motor by the aid of only one wire. On a former occasion I have described a simple form of motor, comprising a single exciting coil, an iron core and disc. Fig. 16 illustrates a modified way of operating such an alternate current motor by currents induced in a transformer connected to one lead, and several other arrangements for circuits for operating a certain class of alternate motors founded on the action of currents of differing phase. In view of the present state of the art it is thought sufficient to describe these arrangements in a few words only. In the diagram, Fig. 16 II. shows a primary coil P, connected with one of its ends to the line L leading from a high tension transformer terminal T_1. In inductive relation to this primary P is a secondary S of coarse wire in the circuit of which is a coil c. The currents induced in the secondary energize the iron core i, which is preferably, but not necessarily, subdivided, and set the metal disc d in rotation. Such a motor M_2, as diagrammatically shown in Fig. 16 II., has been called a "magnetic lag motor," but this expression may be objected to by those who attribute the rotation of the disc to eddy currents circulating in minute paths when the core i is finally subdivided. In order to operate such a motor effectively on the plan indicated the frequencies should not be too high, not more than four or five thousand, though the rotation is produced even with ten thousand per second, or more.

In Fig. 16 I. a motor M_1, having two energizing circuits, A and B, is diagrammatically indicated. The circuit A is connected to the line L, and in series with it is a primary P, which may have its free end connected to an insulated plate P_1, such connection being indicated by the dotted lines. The other motor circuit B is connected to the secondary S, which is in inductive relation to the primary p. When the transformer terminal T_1 is alternately electrified, currents traverse the open line L and also circuit A and primary P. The currents through the latter induce secondary currents in the circuit S, which pass through the energizing coil B of the motor. The currents through the secondary S and those through the primary P differ in phase 90 degrees, or nearly so,



Figs. 22a, 22b and 22c.—Showing the Effect of the Presence of a Gaseous Medium.

and are capable of rotating an armature placed in inductive relation to the circuits A and B.

In Fig. 16 III. a similar motor M_3 with two energizing circuits A_1 and B_1 is illustrated. A primary P, connected with one of its ends to the line L, has a secondary S, which is preferably wound for a tolerably high E. M. F., and to which the two energizing circuits of the motor are connected, one directly to the ends of the secondary, and the other through a condenser C, by the action of which the currents traversing the circuit A_1 and B_1 are made to differ in phase.

In Fig 16 IV. still another arrangement is shown. In this case two primaries P_1 and P_2 are connected to the line L, one through a condenser C of small capacity, and the other directly. The primaries are provided with secondaries S_1 and S_2, which are in series with the energizing circuits A_2 and B_2 and a motor M_2, the condenser C again serving to produce the requisite difference in the phase of the currents traversing the motor circuits. As such phase motors with two or more circuits are now well known in the art, they have been here illustrated diagrammatically. No difficulty whatever is found in operating a motor in the manner indicated, or in similar ways, and although such experiments up to this day present only scientific interest, they may at a period not far distant be carried out with practical objects in view.

It is thought useful to devote here a few remarks to the subject of operating devices of all kinds by means of only one leading wire. It is quite obvious that when high-frequency currents are made use of, ground connections are—at least when the E. M. F. of the currents is great—better than a return wire. Such ground connections are objectionable with steady or low frequency currents, on account of destructive chemical actions of the former, and disturbing influences exerted by both on the neighboring circuits; but with high frequencies these actions practically do not exist. Still, even ground connections become superfluous when the E. M. F. is very high, for soon a condition is reached when the current may be passed more economically through open than through closed conductors. Remote as might seem an industrial application of such single wire transmission of energy to one not experienced in such lines of experiment, it will not seem so to any one who for some time has carried on investigations of such nature. Indeed, I cannot see why such a plan could not be practicable. Nor should it be thought that for carrying at such a plan currents of very high frequency are implicitly required, for just as soon as potentials of, say, 30,000 volts are used the single wire transmission may be effected with low frequencies, and experiments have been made by me from which these inferences are made.

When the frequencies are very high it has been found in laboratory practice quite easy to regulate the effects in the manner shown in diagram Fig. 17. Here two primaries P and P are shown, each connected with one of its ends to the line L, and with the other end to the condenser plates C and C^1, respectively. Near these are placed other condenser plates C_1 and C^1_1, the former being connected to the line L, and the latter to an insulated larger plate P_2. On the primaries are wound secondaries S and S_1 of coarse wire, connected to the devices m and d respectively. By varying the distances of the condenser plates C and C_1, and C_1 and C_1^1, the currents through the secondaries S and S_1 are varied in intensity. The curious feature is the great sensitiveness, the slightest change in the distance of the plates producing considerable variations in the intensity or strength of the currents. The sensitiveness may be rendered extreme by making the frequency such that the primary itself without any plate attached to its free end satisfies, in conjunction with the closed secondary, the condition of resonance. In such condition an extremely small change in the capacity of the free terminal produces great variations. For instance, I have been able to adjust the conditions so that the mere approach of a person to the coil produces a considerable change in the brightness of the lamps attached to the secondary. Such observations and experiments possess of course at present chiefly scientific interest, but they may soon become of practical importance.

Very high frequencies are of course not practicable with motors on account of the necessity of employing iron cores. But one may use sudden discharges of low frequency and thus obtain certain advantages of high-frequency currents without rendering the iron core entirely incapable of following the changes and without entailing a very great expenditure of energy in the core. I have found it quite practicable to operate, with such low frequency disruptive discharges of condensers, alternating current motors. A certain class of such motors which I advanced a few years ago, which contain closed secondary circuits, will rotate quite vigorously when the discharges are directed through the exciting coils. One reason that such a motor operates so well with these discharges is that the difference of phase between the primary and secondary currents is 90 degrees, which is generally not the case with harmonically rising and falling currents of low frequency. It might not be without interest to show an experiment with a simple motor of this kind, inasmuch as it is commonly thought that disruptive discharges are unsuitable for such purposes. The motor is illustrated in Fig. 18. It comprises a rather large iron core i with slots on the top into which are imbedded thick copper washers c c. In proximity to the core is a freely movable metal disc D. The core is provided with a primary exciting coil C, the ends a and b of which are connected to the terminals of the secondary S of an ordinary transformer, the primary P of the latter being connected to an alternating distribution circuit or generator G of low or moderate frequency. The terminals of the secondary S are attached to a condenser C which discharges through an open air gap d d, which may be placed in series or shunt to the coil C. When the conditions are properly chosen the disc D rotates with considerable effort, and the iron core i does not get very perceptibly hot. With currents from a high-frequency alternator, on the contrary, the core gets rapidly hot and the disc rotates with a much smaller effort. To perform the experiment properly it should be first ascertained that the disc D is not set in rotation when the discharge is not occurring at d d. It is preferable to use a large iron core and a condenser of large capacity so as to bring the superimposed quicker oscillation to a very low pitch or to do away with it entirely. By observing certain elementary rules I have also found it practicable to operate ordinary series or shunt direct-current motors with such disruptive discharges, and this can be done with or without a return wire.

Among the various current phenomena observed perhaps the most interesting are those of impedance presented by conductors to currents varying at a rapid rate. In my first paper before the American Institute of Electrical Engineers I have described a few striking observations of this kind. Thus I showed that when such currents or sudden discharges are passed through a thick

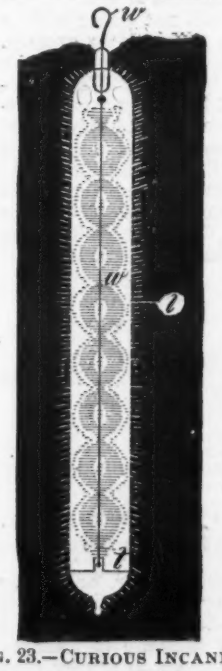


Fig. 23.—Curious Incandescence of a Wire.

Fig. 25.—Illustrating Lateral Diffusion.

metal bar there may be points at the bar only a few inches apart which have a sufficient potential difference between them to maintain at bright incandescence an ordinary filament lamp. I have also described the curious behavior of rarefied gas surrounding a conductor to such sudden rushes of current. These phenomena have been since more carefully studied, and one or two novel experiments of this kind are deemed of sufficient interest to be described here.

With reference to Fig. 19a B and B_1 are very stout copper bars, connected at their lower ends to plates C and C_1, respectively, of a condenser, the opposite plates of the latter being connected to the terminals of the secondary S of a high-tension transformer, the primary P of which is supplied with alternating currents from an

ordinary low-frequency dynamo G, or distribution circuit. The condenser discharges through an adjustable gap d d as usual. By establishing a rapid vibration it was found quite easy to perform the following curious experiment: The bars B and B_1 were joined at the top by a low-voltage lamp l_3; a little lower was placed, by means of clamp c c, a 50-volt lamp l_2 and still lower another 100-volt lamp l_1 and finally at a certain distance below the latter lamp an exhausted tube T. By carefully determining the positions of these devices it was found practicable to maintain them all at their proper illuminating power. Yet they were all connected in multiple arc to the two stout copper bars and required widely different pressures This experiment requires, of course, some time for adjustment, but is quite easily performed.

In Figs. 19b and 19c, two other experiments are illustrated which, unlike the previous experiment, do not require very careful adjustments. In Fig. 20b, two lamps l_1 and l_2, the former a 100-volt and the latter a

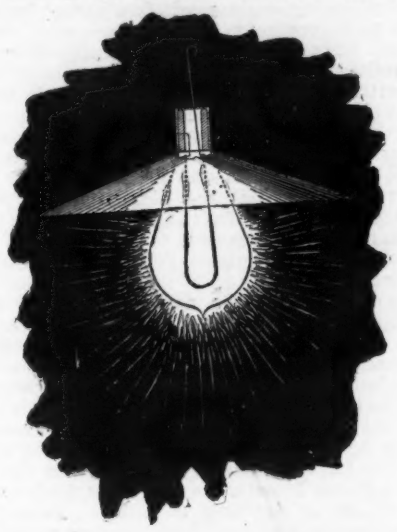


FIG. 24.—UTILIZING THE HEATING EFFECT OF CONDUCTION CURRENT AND BOMBARDMENT.

50-volt, are placed in certain positions as indicated, the 100-volt lamp being below the 50-volt lamp. When the arc is playing at d d, and the sudden discharges passed through the bars B B the 50-volt lamp will, as a rule, burn brightly, or, at least, this result is easily secured, while the 100-volt lamp will burn very low or remain quite dark, Fig. 19b. Now the bars B B may be joined at the top by a thick cross-bar B_2, and it is quite easy to maintain the 100-volt lamp at full candle-power while the 50-volt lamp remains dark, Fig. 19c. These results, as I have pointed out previously, should not be considered to be due exactly to frequency, but rather to the time rate of change which may be great even with low frequencies. A great many other results of the same kind equally interesting, especially to those who are only used to manipulate steady currents, may be obtained, and they afford precious clues in investigating the nature of electric currents.

In the preceding experiments I have already had occasion to show some light phenomena, and it would be now proper to study those in particular; but to make this investigation more complete I think it necessary to first make a few remarks on the subject of electrical resonance, which has to be always observed in carrying out these experiments.

ON ELECTRICAL RESONANCE.

The effects of resonance are being more and more noted by engineers, and are becoming of great importance in the practical operation of apparatus of all kinds with alternating currents. A few general remarks may therefore be made concerning these effects. It is clear, that if we succeed in employing the effects of resonance practically in the operation of electric devices, the return wire will, as a matter of course, become unnecessary, for the electric vibration may be conveyed with one wire just as well, and sometimes even better, than with two. The question first to answer is, then, whether pure resonance effects are producible. Theory and experiment both show that such is impossible in Nature, for as the oscillation becomes more and more vigorous the losses in the vibrating bodies and environing media rapidly increase, and necessarily check the vibration which otherwise would go on increasing forever. It is a fortunate circumstance that pure resonance is not producible, for if it were there is no telling what dangers might not lie in wait for the innocent experimenter. But to a certain degree resonance is producible, the magnitude of the effects being limited by the imperfect conductivity and imperfect elasticity of the media, or, generally stated, by frictional losses. The smaller these losses, the more striking are the effects. The same is the case in mechanical vibration. A stout steel bar may be set in vibration by drops of water falling upon it at proper intervals; and with glass, which is more perfectly elastic, the resonance effect is still more remarkable, for a goblet may be burst by s[illegible]g into it a note of the proper pitch. The electrical [illegible]nance is the more perfectly attained, the smaller the resistance or the impedance of the conducting path, and the more perfect the dielectric. In a Leyden jar discharging through a short, stranded cable of thin wires these requirements are probably best fulfilled, and the resonance effects are, therefore, very prominent. Such is not the case with dynamo machines, transformers and their circuits, or with commercial apparatus in general in which the presence of iron cores complicates or renders impossible the action. In regard to Leyden jars with which resonance effects are frequently demonstrated, I would say that the effects observed are often attributed, but are seldom due, to true resonance, for an error is quite easily made in this respect. This may be undoubtedly demonstrated by the following experiment. Take, for instance, two large insulated metallic plates or spheres, which I shall designate A and B, place them at a certain small distance apart, and charge them from a frictional or influence machine to a potential so high that just a slight increase of the difference of potential between them will cause the small air or insulating space to break down. This is easily reached by making a few preliminary trials. If, now, another plate—fastened on an insulating handle, and connected by a wire to one of the terminals of a high tension secondary of an induction coil, which is maintained in action by an alternator (preferably high frequency)—is approached to one of the charged bodies A or B, so as to be nearer to either one of them, the discharge will invariably occur between them; at least it will if the potential of the coil in connection with the plate is sufficiently high. But the explanation of this will soon be found in the fact that the approached plate acts inductively upon the bodies A and B, and causes a spark to pass between them. When this spark occurs, the charges which were previously imparted to these bodies from the influence machine must needs be lost, since the bodies are brought in electrical connection through the arc formed. Now, this arc is formed whether there be resonance or not. But even if the spark would not be produced, still there is an alternating E. M. F. set up between the bodies when the plate is brought near one of them; therefore, the approach of the plate, if it does not always, actually will, at any rate tend, to break down the air space by inductive action. Instead of the spheres or plates A and B we may take the coatings of a Leyden jar with the same result, and in place of the machine, which is a high frequency alternator preferably, because it is more suitable for the experiment, and also for the argument, we may take another Leyden jar or battery of jars. When such jars are discharging through a circuit of low resistance the same is traversed by currents of very high frequency. The plate may now be connected to one of the coatings of the second jar, and when it is brought near to the first jar just previously charged to a high potential from an influence machine the result is the same as before, and the first jar will discharge through a small air space upon the second being caused to discharge. But both jars and their circuits need not be tuned any closer than a basso profundo is to the note produced by a mosquito, as small sparks will be produced through the air space, or at least the latter will be considerably more strained owing to the setting up of an alternating E. M. F. by induction, which takes place when one of the jars begins to discharge. Again, another error of a similar nature is quite easily made. If the circuits of the two jars are run parallel and close together, and the experiment has been performed of discharging one by the other, and now a coil of wire be added to one of the circuits whereupon the experiment does not succeed, the conclusion that this is due to the fact that the circuits are now not tuned would be far from being safe. For the two circuits act as condenser coatings, and the addition of the coil to one of them is equivalent to bridging them, at the point where the coil is placed, by a small condenser, and the effect of the latter might be to prevent the spark from jumping through the discharge space by diminishing the alternating E. M. F. acting across the same. All these remarks, and many more which might be added but for fear of wandering too far from the subject, are made with the pardonable intention of cautioning the unsuspecting student, who might gain an entirely unwarranted opinion of his skill when seeing every experiment succeed; but they are in no way thrust upon the experienced as novel observations.

In order to make reliable observations of electric resonance effects it is very desirable, if not necessary, to employ an alternator giving currents which rise and fall harmonically, as in working with make and break currents the observations are not always trustworthy, since many phenomena, which depend on the rate of change, may be produced with frequencies widely different. Even when making such observations with an alternator one is apt to be mistaken. When a circuit is connected to an alternator there are an infinite number of values for capacity and self-induction which, in conjunction, will satisfy the condition of resonance. So there are in mechanics an infinite number of tuning forks which will respond to a note of a certain pitch, or loaded springs

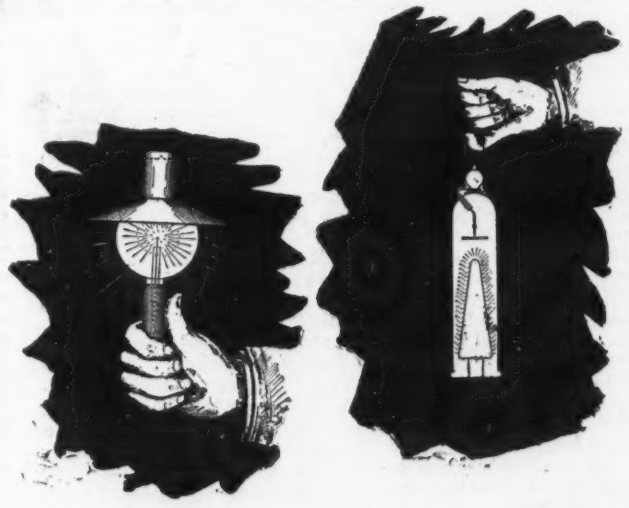


FIG. 26.—INCANDESCENCE OF A SOLID.

FIG. 27.—PHOSPHERENCE.

FIG. 28.—INCANDESCENCE OR PHOSPHERENCE OF RAREFIED GAS.

FIG. 29.—LUMINOSITY OF GAS AT ORDINARY PRESSURE.

FOUR KINDS OF LIGHT EFFECTS BY HIGH FREQUENCY CURRENTS OF HIGH POTENTIAL.

which have a definite period of vibration. But the resonance will be most perfectly attained in that case in which the motion is effected with the greatest freedom. Now in mechanics, considering the vibration in the common medium—that is, air—it is of comparatively little importance whether one tuning fork be somewhat larger than another, because the losses in the air are not very considerable. One may, of course, inclose a tuning fork in an exhausted vessel, and by thus reducing the air resistance to a minimum obtain better resonant action. Still the difference would not be very great. But it would make a great difference if the tuning fork were immersed in mercury. In the electrical vibration it is of enormous importance to arrange the conditions so that the vibration is effected with the greatest freedom. The magnitude of the resonance effect depends, under otherwise equal conditions, on the quantity of electricity set in motion or on the strength of the current driven through the circuit. But the circuit opposes the passage of the currents by reason of its impedance, and, therefore, to secure the best action, it is necessary to reduce the impedance to a minimum. It is impossible to overcome it entirely, but merely in part, for ohmic resistance cannot be overcome. But when the frequency of the impulses is very great, the flow of the current is practically determined by self-induction. Now self-induction can be overcome by combining it with capacity. If the relation between these is such that at the frequency used they annul each other, that is, have such values as to satisfy the condition of resonance, and the greatest quantity of electricity is made to flow through the external circuit, then the best result is obtained. It is simpler and safer to join the condenser in series with the self-induction. It is clear that in such combinations there will be, for a given frequency, and considering only the fundamental vibration, values which will give the best result, with the condenser in shunt to the self-induction coil; of course, more such values than with the condenser in series. But practical conditions determine the selection. In the latter case in performing the experiments one may take a small self-induction and a large capacity or a small capacity and a large self-induction, but the latter is preferable, because it is convenient to adjust a large capacity by small steps. By taking a coil with a very large self-induction, the critical capacity is reduced to a very small value, and the capacity of the coil itself may be sufficient. It is easy, especially by observing certain artifices, to wind a coil through which the impedance will be reduced to the value of the ohmic resistance only, and for any coil there is, of course, a frequency at which the maximum current will be made to pass through the coil. The observation of the relation between self-induction, capacity and frequency is becoming important in the operation of alternate current apparatus, such as transformers or motors, because by a judicious determination of the elements the employment of an expensive condenser becomes unnecessary. Thus it is possible to pass through the coils of an alternating current motor under the normal working conditions the required current with a low E. M. F. and do away entirely with the false current, and the larger the motor the easier such a plan becomes practicable; but it is necessary for this to employ currents of very high potential or high frequency.

In Fig. 20 I is shown a plan which has been followed in the study of the resonance effects by means of a high-frequency alternator. C is a coil of many turns, which is divided in small separate sections for the purposes of adjustment. The final adjustment was made sometimes with a few thin iron wires (though this is not always advisable), or with a closed secondary. The coil C is connected with one of its ends to the line L from the alternator G, and with the other end to one of the plates c of a condenser c c_1, the plate (c_1) of the latter being connected to a much larger plate P_1. In this manner, both capacity and self-induction were adjusted to suit the dynamo frequency.

As regards the rise of potential through resonant action, of course, theoretically, it may amount to anything since it depends on self-induction and resistance, and since these may have any value. But in practice one is limited in the selection of these values, and besides these, there are other limiting causes. One may start with, say, 1,000 volts, and raise the E. M. F. to 50 times that value, but one cannot start with 100,000 and raise it to 10 times that value, because of the losses in the media, which are great, especially if the frequency is high. It should be possible to start with, for instance, two volts from a high or low frequency circuit of a dynamo, and raise the E. M. F. to many hundred times that value. Thus coils of the proper dimensions might be connected each with only one of its ends to the mains from a machine of low E. M. F., and though the circuit of the machine would not be closed in the ordinary acceptance of the term, yet the machine might be burned out if a proper resonance effect would be obtained. I have not been able to produce, nor have I observed with currents from the dynamo machine, such great rises of potential. It is possible, if not probable, that with currents obtained from apparatus containing iron, the disturbing influence of the latter is the cause that these theoretical possibilities cannot be realized. But if such is the case, I attribute it solely to the hysteresis and Foucault current losses in the core. Generally it was necessary to transform upward, when the E. M. F. was very low, and usually an ordinary form of induction coil was employed, but sometimes the arrangement illustrated in Fig. 20 II has been found to be convenient. In this case a coil C is made in a great many sections, a few of these being used as the primary. In this manner both primary and secondary are adjustable. One end of the coil is connected to the line L_1 from the alternator, and the other line, L_2 is connected to the intermediate point of the coil. Such a coil with adjustable primary and secondary will be found also convenient in experiments with the disruptive discharge. When true resonance is obtained, the top of the wave must, of course, be on the free end of the coil, as, for instance, at the terminal of the phosphorescence bulb B. This is easily recognized by observing the potential on a point on the wire w nearer to the coil.

In connection with resonance effects and the problem of transmission of energy over a single conductor, which was previously considered, I would say a few words on a subject which constantly fills my thoughts, and which concerns the welfare of all. I mean the transmission of intelligible signals, or perhaps even power, to any distance without the use of wires. I am becoming daily more con-

vinced of the practicability of the scheme; and though I know full well that the great majority of scientific men will not believe that such results can be practically and immediately realized, yet I think that all consider the developments in recent years by a number of workers to have been such as to encourage thought and experiment in this direction. My conviction has grown so strong that I no longer look upon this plan of energy or intelligence transmission as a mere theoretical possibility, but as a serious problem in electrical engineering, which must be carried out some day. The idea of transmitting intelligence without wires is the natural outcome of the most recent results of electrical investigations.

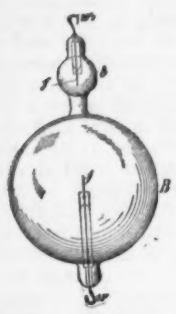


FIG. 30.—SHOWING THE EFFECT OF CONFINING THE GAS AROUND THE ELECTRODE.

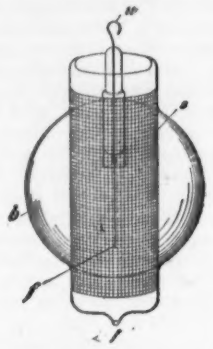


FIG. 31.—SHOWING THE INEFFICIENCY OF A METAL SCREEN.

Some enthusiasts have expressed their belief that telephony to any distance by induction through the air is possible. I cannot stretch my imagination so far, but I do firmly believe that it is practicable to disturb by means of powerful machines the electrostatic condition of the earth and thus transmit intelligible signals and perhaps power. In fact, what is there against the carrying out of such a scheme? We now know that electric vibration may be transmitted through a single conductor. Why then not try to avail ourselves of the earth for this purpose? We need not be frightened by the idea of distance. To the weary wanderer counting the mile-posts the earth may appear very large, but to that happiest of all men, the astronomer, who gazes at the heavens and by their standard judges the magnitude of our globe, it appears very small. And so I think it must seem to the electrician, for when he considers the speed with which an electric disturbance is propagated through the earth all his ideas of distance must completely vanish.

A point of great importance would be, first, to know what is the capacity of the earth and what charge does it contain if electrified? Though we have no positive evidence of a charged body existing in space without other oppositely electrified bodies being near, there is a fair probability that the earth is such a body, for by whatever process it was separated from other bodies—and this is the accepted view of its origin—it must have retained a charge, as occurs in all processes of mechanical separation. If it be a charged body insulated in space its capacity should be extremely small, less than one-thousandth of a farad. But the upper strata of the air are conducting, and so, perhaps, is the medium in free space beyond the atmosphere, and these may contain an opposite charge. Then the capacity might be incomparably greater. In any case it is of the greatest importance to get an idea of what quantity of electricity the earth contains. It is difficult to say whether we shall ever acquire this necessary knowledge, but there is hope that we may, and, that is, by means of electrical resonance. If ever we can ascertain at what period the earth's charge, when disturbed, oscillates with respect to an oppositely electrified system or known circuit, we shall know a fact possibly of the greatest importance to the welfare of the human race. I propose to seek for the period by means of an electrical oscillator, or a source of alternating electric currents. One of the terminals of the source would be connected to earth as, for instance, to the city water mains, the other to an insulated body of large surface. It is possible that the outer conducting air strata or free space contains an opposite charge and that, together with the earth, they form a condenser of very large capacity. In such case the period of vibration may be very low and an alternating dynamo machine might serve for the purpose of the experiment. I would then transform the current to a potential as high as it would be found possible and connect the ends of the high tension secondary to the ground and to the insulated body. By varying the frequency of the currents and carefully observing the potential of the insulated body and watching for the disturbance at various neighboring points of the earth's surface resonance might be detected. Should, as the majority of scientific men in all probability believe, the period be extremely small, then a dynamo machine would not do, and a proper electrical oscillator would have to be produced, and perhaps it might not be possible to obtain such rapid vibrations. But whether this be possible or not, and whether the earth contains a charge or not, and whatever may be its period of vibration, it certainly is possible—for of this we have daily evidence—to produce some electrical disturbance sufficiently powerful to be perceptible by suitable instruments at any point of the earth's surface.

Assume that a source of alternating currents S be connected, as in Fig. 21, with one of its terminals to earth (conveniently to the water mains) and with the other to a body of large surface P. When the electric oscillation is set up there will be a movement of electricity in and out of P, and alternating currents will pass through the earth, converging to, or diverging from, the point C where the ground connection is made. In this manner neighboring points on the earth's surface within a certain radius will be disturbed. But the disturbance will diminish with the distance, and the distance at which the effect will still be perceptible will depend on the quantity of electricity set in motion. Since the body P is insulated, in order to displace a considerable quantity the potential of the source must be excessive, since there would be limitations as to the surface of P. The conditions might be adjusted so that the generator or source S will set up the same electrical movement as though its circuit were closed. Thus it is certainly practicable to impress an electric vibration at least of a certain low period upon the earth, by means of proper machinery. At what distance such a vibration might be made perceptible can only be conjectured. I have on another occasion considered the question how the earth might behave to electric disturbances. There is no doubt that, since in such an experiment the electrical density at the surface could be but extremely small considering the size of the earth, the air would not act as a very disturbing factor and there would be not much energy lost through the action of the air, which would be the case if the density were great. Theoretically, then, it could not require a great amount of energy to produce a disturbance perceptible at great distance, or even all over the surface of the globe. Now it is quite certain that at any point within a certain radius of the source S a properly adjusted self-induction and capacity device can be set in action by resonance. But not only can this be done, but another source S_1, Fig. 21, similar to S, or any number of such sources can be set to work in synchronism with the latter and the vibration thus intensified and spread over a large area, or a flow of electricity produced to or from the source S_1 if the same be of opposite phase to the source S. I think that beyond doubt it is possible to operate electrical devices in a city through the ground or pipe system by resonance from an electrical oscillator located at a central point. But the practical solution of this problem would be of incomparably smaller benefit to man than the realization of the scheme of transmitting intelligence or perhaps power to any distance through the earth or environing medium. If this is at all possible, distance does not mean anything. Proper apparatus must first be produced by means of which the problem can be attacked, and I have devoted much thought to this subject. I am firmly convinced that it can be done and hope that we shall live to see it done.

ON THE LIGHT PHENOMENA PRODUCED BY HIGH-FREQUENCY CURRENTS OF HIGH POTENTIAL, AND GENERAL REMARKS RELATING TO THE SUBJECT.

Returning now to the light effects which it has been the chief object to investigate, it is thought proper to divide these effects into four classes: 1. Incandescence of a solid. 2. Phosphorescence. 3. Incandescence or phosphorescence of a rarefied gas, and 4. Luminosity produced in a gas at ordinary pressure. The first question is, How are these luminous effects produced? In order to answer this question as satisfactorily as I am able to do in the light of accepted views and with the experience acquired, and to add some interest to this demonstration, I shall dwell here upon a feature which I consider of great importance, inasmuch as it promises, besides, to throw a better light upon the nature of most of the phenomena produced by high-frequency electric currents. I have on other occasions pointed out the great importance of the presence of the rarefied gas, or atomic medium in general, around the conductor through which alternate currents of high frequency are passed, as regards the heating of the conductor by the currents. My experiments described some time ago have shown that the higher the frequency and potential difference of the currents, the more important becomes the rarefied gas in which the conductor is immersed, as a factor of the heating. The potential difference, however, is, as I then pointed out, a more important element than the frequency. When both of these are sufficently high, the heating may be almost entirely due to the presence of the rarefied gas. The experiments to follow will show the importance of the rarefied gas, or generally of gas at ordinary or other pressure as regards the incandescence or other luminous effects produced by currents of this kind.

FIG. 32.—ELECTROSTATIC ACTION BETWEEN PRIMARY AND SECONDARY, WITH EXTREMELY HIGH FREQUENCIES.

I take two ordinary 50-volt 16-c. p. lamps which are in every respect alike, with the exception that one has been opened at the top and the air has filled the bulk, while the other is at the ordinary degree of exhaustion of commercial lamps. When I attach the lamp, which is exhausted, to the terminal of the secondary of the coil, which I have already used as in experiments illustrated in Fig. 15*a* for instance, and turn on the current, the filament, as you have before seen, comes to high incandescence. When I attach the second lamp, which is filled with air, instead of the former, the filament still glows, but much less brightly. This experiment illustrates only in part the truth of the statements before made. The importance of the filament's being immersed in rarefied gas is plainly noticeable, but not to such a degree as might be desirable. The reason is that the secondary of this coil is wound for low tension, having only 150 turns, and the potential difference at the terminals of the lamp is therefore small. Were I to take another coil with many more turns in the secondary, the effect would be increased, since it depends partially on the potential difference, as before remarked. But since the effect likewise depends on the frequency, it may be properly stated that it depends on the time rate of the variation of the potential difference. The greater this variation, the more important becomes the gas as an element of heating. I can produce a much greater rate of variation in another way, which besides has the advantage of doing away with the objections which might be made in the experiment just shown, even if both the lamps were connected in series or multiple arc to the coil, namely, that in consequence of the reactions existing between the primary and secondary coil the conclusions are rendered uncertain. This result I secure by charging from an ordinary transformer, which is fed from the alternating current supply station, a battery of condensers, and discharging the latter directly through a circuit of small self-induction, as before illustrated in Figs. 19a, 19b, 19c.

In Figs. 22a, 22b and 22c the heavy copper bars B, B_1 are connected to the opposite coatings of a battery of condensers, or generally in such way that the high frequency or sudden discharges are made to traverse them. I connect first an ordinary 50-volt incandescent lamp to the bars by means of the clamps c, c. The discharges being passed through the lamp, the filament is rendered incandescent, though the current through it is very small, and would not be nearly sufficient to produce a visible effect under the conditions of ordinary use of the lamp. Instead of this I now attach to the bars another lamp exactly like the first, but with the seal broken off, the bulb being therefore filled with air at ordinary pressure. When the discharges are directed through the filament, as before, it does not become incandescent. But the result might still be attributed to one of the many possible reactions. I therefore connect both the lamps in multiple arc as illustrated in Fig. 22a. Passing the discharges through both the lamps, again the filament in the exhausted lamp l glows very brightly, while that in the non-exhausted lamp l_1 remains dark, as, previously. But it should not be thought that the latter lamp is taking only a small fraction of the energy supplied to both the lamps; on the contrary, it may consume a considerable portion of the energy, and it may become even hotter than the one which burns brightly. In this experiment the potential difference at the terminals of the lamps varies in sign theoretically three to four million times a second. The ends of the filaments are correspondingly electrified, and the gas in the bulbs is violently agitated and a large portion of the supplied energy is thus converted into heat. In the non-exhausted bulb, there being a few million times more gas molecules than in the exhausted one, the bombardment, which is most violent at the ends of the filament, in the neck of the bulb, consumes a large portion of the energy without producing a any visible effect. The reason is that, there being many molecules, the bombardment is quantitatively considerable, but the individual impacts are not very violent, as the speeds of the molecules are comparatively small owing to the small free path. In the exhausted bulb, on the contrary, the speeds are very great, and the individual impacts are violent and therefore better adapted to produce a visible effect. Besides, the convection of heat is greater in the former bulb. In both the bulbs the current traversing the filaments is very small, incomparably smaller than that which they require on an ordinary low-frequency circuit. The potential difference, however, at the ends of the filaments is very great and might be possibly 20,000 volts or more if the filaments were straight and their ends far apart. In the ordinary lamp a spark generally occurs between the ends of the filament or between the platinum wires outside, before such a difference of potential can be reached.

It might be objected, in the experiment before shown, that, the lamps being in multiple arc, the exhausted lamp might take a much larger current, and that the effect observed might not be exactly attributable to the action of the gas in the bulbs. Such objections will lose much weight if I connect the lamps in series with the same result. When this is done, and the discharges are directed through the filaments, it is again noted that the filament in the non-exhausted bulb, l_1, remains dark, while that in the exhausted one, l, glows even more intensely than under its normal conditions of working, Fig. 22b. According to general ideas, the current through the filaments should now be the same, were it not modified by the presence of the gas around the filaments.

At this juncture I may point out another interesting feature, which illustrates the effect of the rate of change of potential of the currents. I will leave the two lamps connected in series to the bars B, B_1, as in the previous experiment, Fig. 22b, but will presently reduce considerably the frequency of the currents, which was excessive in the experiment just before shown. This I may do by inserting a self-induction coil in the path of the discharges, or by augmenting the capacity of the condensers. When I now pass these low frequency discharges through the lamps, the exhausted lamp, l, again is as bright as before, but it is noted also that the non exhausted lamp, l_1, glows, though not quite as intensely as the other. Reducing the current through the lamps, I may bring the filament in the latter lamp to redness, and, though the filament in the exhausted lamp l, is bright, Fig. 22c, the degree of its incandescence is much smaller than in Fig. 22b, when the currents were of a much higher frequency.

In these experiments the gas acts in two opposite ways in determining the degree of the incandescence of the filaments; that is, by convection and bombardment. The higher the frequency and potential of the currents, the more important becomes the bombardment. The convection, on the contrary, should be the smaller, the higher the frequency. When the currents are steady, there is practically no bombardment, and convection may therefore with such currents also considerably modify the degree of incandescence and produce results similar to those just before shown. Thus, if two lamps exactly alike, one exhausted and one not exhausted, are connected in multiple arc or series to a direct current machine, the filament in the non-exhausted lamp will require a considerably greater current to be rendered incandescent. This result is entirely due to convection, and the effect is the more prominent the thinner the filament. Prof. Ayrton and Mr. Kilgour some time ago published quantitative results concerning the thermal emissivity by radiation and convection, in which the effect of thin wires was clearly shown. This effect may be strikingly illustrated by preparing a number of small, short glass tubes, each containing through its axis the thinnest obtainable platinum wire. If these tubes be highly exhausted, a number of them may be connected in multiple arc to a direct current machine, and all of the wires may be kept at incandescence with a smaller current than that required to render incandescent a single one of the wires if the tube be not exhausted. Could the tubes be so highly exhausted that convection would be nil, then the relative amounts of heat given off by convection and radiation could be determined without the difficulties attending thermal quantitative measurements. If a source of electric impulses of high frequency and very high potential is employed, a still greater number of the tubes may be taken and the wires rendered incandescent by a current not capable of warming perceptibly a wire of the same size immersed in air at ordinary pressure, and conveying the energy to all of them.

I may here describe a result which is still more interesting, and to which I have been led by the observation of these phenomena. I noted that small differences in the

FIG. 33.—CARBON DEPOSIT IN TUBE IN A MAGNETIC FIELD.

density of the air produced a considerable difference in the degree of incandescence of the wires, and I thought that, since in a tube, through which a luminous discharge is passed, the gas is generally not of uniform density, a very thin wire contained in the tube might be rendered incandescent at certain places of smaller density of the gas, while it would remain dark at the places of greater density, where the convection would be greater and the bombardment less intense. Accordingly a tube, t, was prepared, as illustrated in Fig. 23, which contained through the middle a very fine platinum wire w. The tube was exhausted to a moderate degree, and it was found that when it was attached to the terminal of a high frequency coil the platinum wire w would, indeed, become incandescent in patches, as illustrated in Fig. 23. Later a

number of these tubes with one or more wires were prepared, each showing this result. The effect was best noted when the striated discharge occurred in the tube, but was also produced when the striæ were not visible, showing that, even then, the gas in the tube was not of uniform density. The position of the striæ was generally such that the rarefactions corresponded to the places of incandescence or greater brightness on the wire w. But in a few instances it was noted that the bright spots on the wire were covered by the dense parts of the striated discharge as indicated by 1 in Fig. 23, though the effect was barely perceptible. This was explained in a plausible way by assuming, that the convection was not widely different in the dense and rarefied places, and that the bombardment was greater on the dense places of the striated discharge. It is, in fact, often observed in bulbs that under certain conditions a thin wire is brought to higher incandescence when the air is not too highly rarefied. This is the case when the potential of the coil is not high enough for the vaccum, but the result may be attributed to many different causes. In all cases this curious phenomenon of incandescence disappears when the tube, or rather the wire, acquires throughout a uniform temperature.

Disregarding now the modifying effect of convection, there are then two distinct causes which determine the incandescence of a wire or filament with varying currents; that is, conduction current and bombardment. With steady currents we have to deal only with the former of these two causes, and the heating effect is a minimum, since the resistance is least to steady flow. When the current is a varying one, the resistance is greater, and hence the heating effect is increased. Thus, if the rate of change of the current is very great, the resistance may increase to such an extent that the filament is brought to incandescence with inappreciable currents; and we are able to take a short and thick block of carbon or other material and bring it to bright incandescence with a current incomparably smaller than that required to bring to the same degree of incandescence an ordinary thin lamp filament with a steady or low frequency current. This result is important, and illustrates how rapidly our views on these subjects are changing and how quickly our field of knowledge is extending. In the art of incandescent lighting, to view this result in one aspect only, it has been commonly considered as an essential requirement for practical success that the lamp filament should be thin and of high resistance, But now we know that the resistance to the steady flow of the filament does not mean anything ; the filament might as well be short and thick ; for if it be immersed in rarefied gas it will become incandescent by the passage of a small current. It all depends on the frequency and potential of the currents. We may conclude from this that it would be of advantage , so far as the lamp is considered, to employ high frequencies for lighting, as they allow the use of short and thick filaments and smaller currents.

If a wire or filament be immersed in a homogeneous medium, all the heating is due to true conduction current; but if it be inclosed in an exhausted vessel, the conditions are entirely different. Here the gas begins to act, and the heating effect of the conduction current, as shown in many experiments, may be very small compared with that of the bombardment. This is especially the case if the circuit is not closed and the potentials, of course, very high. Suppose a fine filament inclosed in an exhausted vessel be connected with one of its ends to the terminal of a high tension coil, and with its other end to a large insulated plate. Though the circuit is not closed, the filament, as I have before shown, is brought to incandescence. If the frequency and potential be comparatively low, the filament is heated by the current passing *through* it. If the frequency and potential, and principally the latter, be increased, the insulated plate need be but very small, or may be done away with entirely; still the filament will become incandescent, practically all the heating being then due to the bombardment. A practical way of combining both the effects of conduction current and bombardment is illustrated in Fig. 24, in which an ordinary lamp is shown provided with a very thin filament which has one of the ends of the latter connected to a shade serving the purpose of the insulated plate, and the other end to the terminal of a high tension source. It should not be thought that only rarefied gas is an important factor in the heating of a conductor by varying currents, but gas at ordinary pressure may become important, if the potential difference and frequency of the currents is excessive. On this subject I have already stated that when a conductor is fused by a stroke of lightning the current through it may be exceedingly small, not even sufficient to heat the conductor perceptibly were the latter immersed in a homogeneous medium.

From the preceding it is clear that when a conductor of high resistance is connected to the terminals of a source of high frequency currents of high potential, there may occur considerable dissipation of energy, principally on the ends of the conductor, in consequence of the action of the gas surrounding the conductor. Owing to this, the current through a section of the conductor at a point midway between its ends may be much smaller than through a section near the ends. Furthermore, the current passes principally through the outer portions of the conductor, but this effect is to be distinguished from the skin effect as ordinarily interpreted, for the latter would or should occur also in a continuous incompressible medium. If a great many incandescent lamps are connected in series to a source of such currents, the lamps at the ends may burn brightly, whereas those in the middle may remain entirely dark. This is due principally to bombardment, as before stated. But even if the currents be steady, provided the difference of potential is very great, the lamps at the ends will burn more brightly than those in the middle. In such case there is no rhymthmical bombardment and the result is produced entirely by leakage. This leakage or dissipation into space when the tension is high is considerable when incandescent lamps are used, and still more considerable with arcs, for the latter act like flames. Generally, of course, the dissipation is much smaller with steady than with varying currents.

I have contrived an experiment which illustrates in an interesting manner the effect of lateral diffusion. If a very long tube is attached to the terminal of a high frequency coil, the luminosity is greatest near the terminal and falls off gradually toward the remote end. This is more marked if the tube is narrow.

A small tube about one-half inch in diameter and twelve inches long, Fig. 25, has one of its ends drawn out into a fine fibre f nearly three feet long. The tube is placed in a brass socket T which can be screwed on the terminal T_1 of the induction coil. The discharge passing through the tube first illuminates the bottom of the same, which is of comparatively large section ; but through the long glass fibre the discharge cannot pass. But gradually the rarefied gas inside becomes warmed and more conducting, and the discharge spreads into the glass fibre. This spreading is so slow that it may take half a minute or more until the discharge has worked through up to the top of the glass fibre, then presenting the appearance of a strongly luminous thin thread. By adjusting the potential at the terminal the light may be made to travel upward at any speed. Once, however, the glass fibre is heated the discharge breaks through its entire length instantly. The interesting point to be noted is that, the higher the frequency of the currents, or in other words the greater relatively the lateral dissipation, at a slower rate may the light be made to propagate through the fibre. This experiment is best performed with a highly exhausted and freshly made tube. When the tube has been used for some time the experiment often fails. It is possible that the gradual and slow impairment of the vacuum is the cause. This slow propagation of the discharge through a very narrow glass tube corresponds exactly to the propagation of heat through a bar warmed at one end. The quicker the heat is carried away laterally the longer time it will take for the heat to warm the remote end. When the current of a low frequency coil is passed through the fibre from end to end, then the lateral dissipation is small, and the discharge instantly breaks through almost without exception.

After these experiments and observations, which have shown the importance of the discontinuity or atomic structure of the medium, and which will serve to explain, in a measure at least, the nature of the four kinds of light effects produceable with these currents, I may now give you an illustration of these effects. For the sake of interest I may do this in a manner which to many of you might be novel. You have seen before that we may now convey the electric vibration to a body by means of a single wire or conductor of any kind. Since the human frame is conducting I may convey the vibration through my body.

First, as in some previous experiments, I connect my body with one of the terminals of a high tension transformer, and take in my hand an exhausted bulb which contains a small carbon button mounted upon a platinum wire leading to the outside of the bulb, and the button is rendered incandescent as soon as the transformer is set to work (Fig. 26). I may place a conducting shade on the bulb which serves to intensify the action, but it is not necessary. Nor is it required that the button should be in conducting connection with the hand through a wire leading through the glass, for sufficient energy may be transmitted through the glass itself by inductive action to render the button incandescent.

Next I take a highly exhausted bulb containing a strongly phosphorescent body, above which is mounted a small plate of aluminum on a platinum wire leading to the outside, and the currents flowing through my body excite intense phosphorescence in the bulb, Fig. 27. Next again I take in my hand a simple exhausted tube, and in the same manner the gas inside the tube is rendered highly incandescent or phosphorescent, Fig. 28. Finally, I may take in my hand a wire—bare or covered with thick insulation, it is quite immaterial ; the electric vibration is so intense as to cover the wire with a luminous film, Fig 29.

A few words must now be devoted to each of these phenomena. In the first place, I will consider the incandescence of a button or of a solid in general, and dwell upon some facts which apply equally to all these phenomena. It was pointed out before that when a thin conductor, such as a lamp filament, for instance, is connected with one of its ends to the terminal of a transformer of high tension, the filament is brought to incandescence partly by a conduction current and partly by bombardment. The shorter and thicker the filament, the more important becomes the latter, and, finally, reducing the filament to a mere button, all the heating must practically be attributed to the bombardment. So in the experiment before shown, the button is rendered incandescent by the rhythmical impact of freely movable small bodies in the bulb. These bodies may be the molecules of the residual gas, particles of dust or lumps torn from the electrode; whatever they are, it is certain that the heating of the button is essentially connected with the pressure of such freely movable particles, or of atomic matter in general in the bulb. The heating is the more intense the greater the number of impacts per second and the greater the energy of each impact. Yet the button would be heated also if it were connected to a source of steady potential. In such a case electricity would be carried away from the button by the freely movable carriers or particles flying about, and the quantity of electricity thus carried away might be sufficient to bring the button to incandescence by its passage through the latter. But the bombardment could not be of great importance in such case. For this reason it would require a comparatively very great supply of energy to the button to maintain it at incandescence with a steady potential. The higher the frequency of the electric impulses, the more economically can the button be maintained at incandescence. One of the chief reasons why this is so, is, I believe, that with impulses of very high frequency there is less exchange of the freely movable carriers around the electrode, and this means that in the bulb the heated matter is better confined to the neighborhood of the button. If a double bulb, as illustrated in Fig. 30, be made, comprising a large globe B and a small one b, each containing as usual a filament f mounted on a platinum wire w and w_1 it is found, that if the filaments f f be exactly alike, it requires less energy to keep the filament in the globe b at a certain degree of incandescence than in the large globe, B. This is due to the confinement of the movable particles around the button. In this case, it is also ascertained, that the filament in the small globe b is less deteriorated when maintained a certain length of time at incandescence. This is a necessary consequence of the fact that the gas in the small bulb becomes strongly heated and therefore a very good conductor, and less work is then performed on the button, since the bombardment becomes less intense as the conductivity of the gas increases. In this construction, of course, the small bulb becomes very hot, and when it reaches an elevated temperature the convection and radiation on the outside increase. On another occasion, I have shown bulbs in which this drawback was largely avoided. In these instances a very small bulb, containing a refractory button, was mounted in a large globe, and the space between the walls of both was highly exhausted. The outer large globe remained comparatively cool in such constructions. When the large globe was on the pump and the vacuum between the walls maintained permanent by the continuous action of the pump, the outer globe would remain quite cold, while the button in the small bulb was kept at incandescence. But when the seal was made, and the button in the small bulb maintained incandescent some length of time, the large globe too would become warmed. From this I conjectured that if vacuous space (as Prof. Dewar finds) cannot convey heat, it is so merely in virtue of our rapid motion through space or, generally speaking, by the motion of the medium relatively to us, for a permanent condition could not be maintained without the medium being constantly renewed. A vacuum cannot, according to all evidence, be permanently maintained around a hot body.

In these constructions, before mentioned, the small bulb inside would, at least in the first stages, prevent all bombardment against the outer, large globe. It occurred to me then, to ascertain how a metal sieve would behave in this respect, and several bulbs, as illustrated in Fig. 31, were prepared for this purpose. In a globe, b, was mounted a thin filament f (or button) upon a platinum wire w passing through a glass stem and leading to the outside of the globe. The filament f was surrounded by a metal sieve s. It was found in experiments with such bulbs that a sieve with wide meshes apparently did not in the slightest affect the bombardment against the globe b. When the vacuum was high, the shadow of the sieve was clearly projected against the globe, and the latter would get hot in a short while. In some bulbs the sieve was connected to a platinum wire sealed in the glass. When this wire was connected to the other terminal of the induction coil (the E. M. F. being kept low in this case) or to an insulated plate, the bombardment against the outer globe b was diminished. By taking a sieve with fine meshes the bombardment against the globe b was diminished, but even then if the exhaustion was carried very far, and when the potential of the transformer was very high, the globe b would be bombarded and heated quickly, though no shadow of the sieve was visible owing to the smallness of the meshes. But a glass tube or other continuous body mounted so as to surround the filament, did entirely cut off the bombardment and for a while the outer globe b would remain perfectly cold. Of course, when the glass tube was sufficiently heated, the bombardment against the outer globe could be noted at once. The experiments with these bulbs seemed to show that the speeds of the projected molecules or particles must be considerable (though quite insignificant when compared with that of light), otherwise it would be difficult to understand how they could traverse a fine metal sieve without being affected, unless it were found that such small particles or atoms cannot be acted upon directly at measurable distances. In regard to the speed of the projected atoms, Lord Kelvin has recently estimated it at about one kilometre a second or thereabouts in an ordinary Crookes bulb. As the potentials obtainable with a disruptive discharge coil are much higher than with ordinary coils, the speeds must, of course, be much greater when the bulbs are lighted from such a coil. Assuming the speed to be as high as five kilometres and uniform through the whole trajectory, as it should be in a very highly exhausted vessel, then if the alternate electrifications of the electrode would be of a frequency of five million, the greatest distance a particle could get away from the electrode would be one millimetre, and if it could be acted upon directly at that distance, the exchange of electrode matter or of the

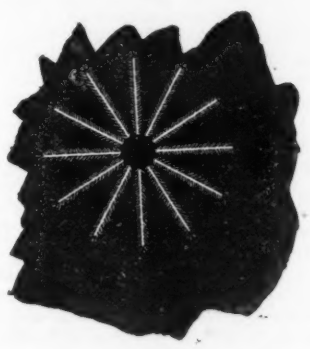
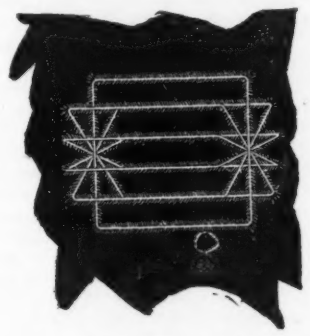
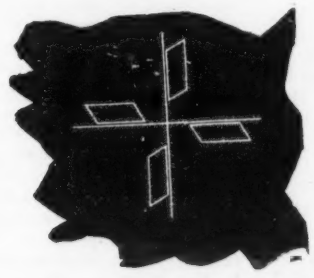


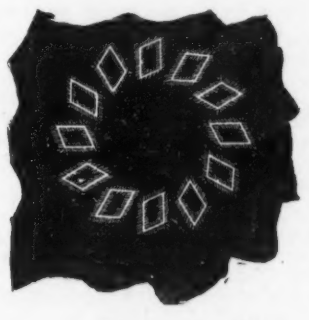
FIG. 34.—SPOKE WHEEL.



DRUM WINDING.



ALTERNATE MOTOR WINDING.



RING WINDING.

SOME OF THE DESIGNS PRODUCED BY INTERMITTENT DISCHARGES.

atoms would be very slow, and there would be practically no bombardment against the bulb. This at least should be so, if the action of an electrode upon the atoms of the residual gas would be such as upon electrified bodies which we can perceive. A hot body inclosed in an exhausted bulb produces always atomatic bombardment, but a hot body has no definite rhythm, for its molecules perform vibrations of all kinds.

If a bulb containing a button or filament be exhausted as high as is possible with the greatest care and by the use of the best artifices, it is often observed that the discharge cannot, at first, break through, but after some time, probably in consequence of some changes within the bulb, the discharge finally passes through and the button is rendered incandescent. In fact, it appears that the higher the degree of exhaustion, the easier is the incandescence produced. There seems to be no other causes which the incandescence might be attributed in such case, except to the bombardment or similar action of the residual gas, or of particles of matter in general. But if the bulb be exhausted with the greatest care, can these play an important part? Assume the vacuum in the bulb to be tolerably perfect, the great interest then centres in the question: Is the medium which pervades all space continuous or atomic? If atomic then the heating of a conducting button or filament in an exhausted vessel might be due largely to etherbombardment, and then the heating of a conductor in general through which currents of high frequency or high potential are passed must be modified by the behavior of such medium; then also the skin effect, the apparent increase of the ohmic resistance, etc., admit, partially, at least, of a different explanation.

It is certainly more in accordance with many phenomena observed with high-frequency currents to hold that all space is pervaded with free atoms, rather than to assume that it is devoid of these, and dark and cold, for so it must be, filled with a continuous medium, since in such there can be neither heat nor light. Is, then, energy transmitted by independent carriers or by the vibration of a continuous medium? This important question is by no means as yet positively answered. But most of the effects which are here considered, especially the light effects, incandescence, or phosphorescence, involve the presence of free atoms and would be impossible without these.

In regard to the incandescence of a refractory button (or filament) in an exhausted receiver, which has been one of the subjects of this investigation, the chief experiences, which may serve as a guide in constructing such bulbs, may be summed up as follows: 1. The button should be as small as possible, spherical, of a smooth or polished surface and of refractory material, which withstands evaporation best. 2. The support of the button should be very thin and screened by an aluminum and mica sheet, as I have described on another occasion. 3. The exhaustion of the bulb should be as high as possible. 4. The frequency of the currents should be as high as practicable. 5. The currents should be of a harmonic rise and fall, without sudden interruptions. 6. The heat should be confined to the button by inclosing the same in a small bulb or otherwise. 7. The space between the walls of the small bulb and the outer globe should be highly exhausted.

Most of the considerations which apply to the incandescence of a solid just considered may likewise be applied to phosphorescence. Indeed, in an exhausted vessel the phosphorescence is, as a rule, primarily excited by the powerful beating of the electrode stream of atoms against the phosphorescent body. Even in many cases, where there is no evidence of such a bombardment, I think that phosphorescence is excited by violent impacts of atoms, which are not necessarily thrown off from the electrode, but are acted upon from the same inductively through the medium or through chains of other atoms. That mechanical shocks play an important part in exciting phosphorescence in a bulb may be seen from the following experiment. If a bulb, constructed as that illustrated in Fig. 10, be taken and exhausted with the greatest care so that the discharge cannot pass, the filament f acts by electrostatic induction upon the tube t, and the latter is set in vibration. If the tube o be rather wide, about an inch or so, the filament may be so powerfully vibrated that whenever it hits the glass tube it excites phosphorescence. But the phosphorescence ceases when the filament comes to rest. The vibration can be arrested and again started by varying the frequency of the currents. Namely, the filament has its own period of vibration, and if the frequency of the currents is such that there is resonance, it is set easily vibrating, though the potential of the currents be small. I have often observed that the filament in the bulb is destroyed by such mechanical resonance. The filament vibrates as a rule so rapidly that it cannot be seen, and the experimenter may at first be mystified. When such an experiment as the one described is carefully performed, the potential of the currents need be extremely small, and for this reason I infer that the phosphoresence is then due to the mechanical shock of the filament against the glass, just as it is produced by striking a loaf of sugar with a knife. The mechanical shock produced by the projected atoms is easily noted when a bulb containing a button is grasped in the hand and the current turned on suddenly. I believe that a bulb could be shattered by observing the conditions of resonance.

In the experiment before cited it is, of course, open to say that the glass tube upon coming in contact with the filament retains a charge of a certain sign upon the point of contact. If now the filament again touches the glass at the same point while it is oppositely charged, the charges equalize under evolution of light. But nothing of importance would be gained by such an explanation. It is unquestionable that the initial charges given to the atoms or to the glass play some part in exciting phosphorescence. So, for instance, if a phosphorescent bulb be first excited by a high frequency coil by connecting it to one of the terminals of the latter and the degree of luminosity noted, and then the bulb be highly charged from a Holtz machine by attaching it preferably to the positive terminal of the machine, it is found that when the bulb is again connected to the terminal of the high frequency coil, the phosphorescence is far more intense. On another occasion I have considered the possibility of some phosphorescent phenomena in bulbs being produced by the incandescence of an infinitesimal layer on the surface of the phosphorescent body. Certainly, the impacts of the atoms are powerful enough to produce intense incandescence by the collisions, since they bring quickly to a high temperature a body of considerable bulk. If any such effect exists, then the best appliance for producing phosphorescence in a bulb, which we know so far, is a disruptive discharge coil giving an enormous potential with but few fundamental discharges, say 25-30 per second, just enough, to produce a continuous impression upon the eye. It is a fact that such a coil excites phosphorescence under most any condition and at all degrees of exhaustion, and I have observed effects which appear to be due to phosphorescence even at ordinary pressures of the atmosphere, when the potentials are extremely high. But if phosphorescent light is produced by the equalization of charges of electrified atoms (whatever this may mean ultimately), then the higher the frequency of the impulses or alternate electrifications, the more economical will be the light production. It is a long known and noteworthy fact that all the phosphorescent bodies are poor conductors of electricity and heat, and that all bodies cease to emit phosphorescent light when they are brought to a certain temperature. Conductors on the contrary do not possess this quality. There are but few exceptions to the rule. Carbon is one of them. Becquerel noted that carbon phosphorescences at a certain elevated temperature preceding the dark red. This phenomenon may be easily observed in bulbs provided with a rather large carbon electrode (say a sphere of six millimetres diameter). If the current is turned on after a few seconds, a snow white film covers the electrode, just before it gets dark red. Similar effects are noted with other conducting bodies, but many scientific men will probably not attribute them to true phosphorescence. Whether true incandescence has anything to do with phosphorescence excited by atomic impact or mechanical shocks still remains to be decided, but it is a fact that all conditions, which tend to localize and increase the heating effect at the point of impact, are almost invariably the most favorable for the production of phosphorescence. So, if the electrode be very small, which is equivalent to saying in general, that the electric density is great, if the potential be high, and if the gas be highly rarefied, all of which things imply high speed of the projected atoms, or matter, and consequently violent impacts—the phosphorescence is very intense. If a bulb provided with a large and small electrode be attached to the terminal of an induction coil, the small electrode excites phosphorescence while the large one may not do so, because of the smaller electric density and hence smaller speed of the atoms. A bulb provided with a large electrode may be grasped with the hand while the electrode is connected to the terminal of the coil and it may not phosphoresce; but if instead of grasping the bulb with the hand, the same be touched with a pointed wire, the phosphorescence at once spreads through the bulb, because of the great density at the point of contact. With low frequencies it seems that gases of great atomic weight excite more intense phosphorescence than those of smaller weight, as for instance, hydrogen. With high frequencies the observations are not sufficiently reliable to draw a conclusion. Oxygen, as is well known, produces exceptionally strong effects, which may be in part due to chemical action. A bulb with hydrogen residue seems to be most easily excited. Electrodes which are most easily deteriorated produce more intense phosphorescence in bulbs, but the condition is not permanent because of the impairing of the vacuum and the deposition of the electrode matter upon the phosphorescent surfaces. Some liquids as oils, for instance, produce magnificent effects of phosphorescense (or fluorescence?), but they last only a few seconds. So if a bulb have a trace of oil on the walls and the current is turned on, the phophorescence only persists for a few moments until the oil is carried away. Of all bodies so far tried, sulphide of zinc seems to be the most susceptible to phosphorescence. Some samples obtained through the kindness of Prof. Henry in Paris, were employed in many of these bulbs. One of the defects of this sulphide is, that it loses its quality of emitting light when brought to a temperature which is by no means high. It can therefore, be used only for feeble intensities. An observation which might deserve notice is, that when violently bombarded from an aluminium electrode it assumes a black color, but singularly enough, it returns to the original condition when it cools down.

The most important fact arrived at in pursuing investigations in this direction is, that in all cases it is necessary, in order to excite phosphorescence with a minimum amount of energy, to observe certain conditions. Namely, there is always, no matter what the frequency of the currents, degree of exhaustion and character of the bodies in the bulb, a certain potential (assuming the bulb excited from one terminal) or potential difference (assuming the bulb to be excited with both terminals) which produces the most economical result. If the potential be increased, considerable energy may be wasted without producing any more light, and if it be diminished, then again the light production is not as economical. The exact condition under which the best result is obtained seems to depend on many things of a different nature, and it is to be yet investigated by other experimenters, but it will certainly have to be observed when such phosphorescent bulbs are operated, if the best results are to be attained.

Coming now to the most interesting of these phenomena, the incandescence or phosphorescence of gases, at low pressures or at the ordinary pressure of the atmosphere, we must seek the explanation of these phenomena in the same primary causes, that is, in shocks or impacts of the atoms. Just as molecules or atoms beating upon a solid body excite phosphorescence in the same or render it incandescent, so when colliding among themselves they produce similar phenomena. But this is a very insufficient explanation and concerns only the crude mechanism. Light is produced by vibrations which go on at a rate almost inconceivable. If we compute, from the energy contained in the form of known radiations in a definite space the force which is necessary to set up such rapid vibrations, we find, that though the density of the ether be incomparably smaller than that of any body we know, even hydrogen, the force is something surpassing comprehension. What is this force, which in mechanical measure may amount to thousands of tons per square inch? It is electrostatic force in the light of modern views. It is impossible to conceive how a body of measurable dimensions could be charged to so high a potential that the force would be sufficient to produce these vibrations. Long before any such charge could be imparted to the body it would be shattered into atoms. The sun emits light and heat, and so does an ordinary flame or incandescent filament, but in neither of these can the force be accounted for if it be assumed that it is associated with the body as a whole. Only in one way may we account for it, namely, by identifying it with the atom. An atom is so small, that if it be charged by coming in contact with an electrified body and the charge be assumed to follow the same law as in the case of bodies of measurable dimensions, it must retain a quantity of electricity which is fully capable of accounting for these forces and tremendous rates of vibration. But the atom behaves singularly in this respect, it always takes the same "charge."

It is very likely that reasonant vibration plays a most important part in all manifestations of energy in nature. Throughout space all matter is vibrating, and all rates of vibration are represented, from the lowest musical note to the highest pitch of the chemical rays, hence an atom, or complex of atoms, no matter what its period, must find a vibration with which it is in resonance. When we consider the enormous rapidity of the light vibrations, we realize the impossibility of producing such vibrations directly with any apparatus of measurable dimensions, and we are driven to the only possible means of attaining the object of setting up waves of light by electrical means and economically, that is, to affect the molecules or atoms of a gas, to cause them to collide and vibrate. We then must ask ourselves—How can free molecules or atoms be affected?

It is a fact that they can be affected by electrostatic force, as is apparent in many of these experiments. By varying the electrostatic force we can agitate the atoms, and cause them to collide under evolution of heat and light. It is not demonstrated beyond doubt that we can affect them otherwise. If a luminous discharge is produced in a closed exhausted tube, do the atoms arrange themselves in obedience to any other but to electrostatic force acting in straight lines from atom to atom? Only recently I investigated the mutual action between two circuits with extreme rates of vibration. When a battery of a few jars (c c c c, Fig. 32) is discharged through a primary P of low resistance (the connections being as illustrated in Figs. 19a, 19b and 19c), and the frequency of vibration be many million there are great differences of potential between points on the primary not more than a few inches apart. These differences may be 10,000 volts per inch, if not more, taking the maximum value of the E. M. F. The secondary s is therefore acted upon by electrostatic induction, which is in such extreme cases of much greater importance than the electrodynamic. To such sudden impulses the primary as well as the secondary are poor conductors, and therefore great differences of potential may be produced by electrostatic induction between adjacent points on the secondary. Then sparks may jump between the wires and streamers become visible in the dark if the light of the discharge through the spark gap d d be carefully excluded. If now we substitute a closed vacuum tube for the metallic secondary s, the differences of potential produced in the tube by electrostatic induction from the primary are fully sufficient to excite portions of it; but as the points of certain differences of potential on the primary are not fixed, but are generally constantly changing in position, a luminous band is produced in the tube, apparently not touching the glass, as it should, if the points of maximum and minimum differences of potential were fixed on the primary. I do not exclude the possibility of such a tube being excited only by electro-dynamic induction, for very able physicists hold this view; but in my opinion, there is as yet no positive proof given that atoms of a gas in a closed tube may arrange themselves in chains under the action of an electromotive impulse produced by electro-dynamic induction in the tube. I have been unable so far to produce striae in a tube, however long, and at whatever degree of exhaustion, that is, striae at right angles to the supposed direction of the discharge or the axis of the tube, but I have distinctly observed in a large bulb, in which a wide luminous band was produced by passing a discharge of a battery through a wire surrounding the bulb, a circle of feeble luminosity between two luminous bands, one of which was more intense than the other. Furthermore, with my present experience I do not think that such a gas discharge in a closed tube can vibrate, that is, vibrate as a whole. I am convinced that no discharge through a gas can vibrate. The atoms of a gas behave very curiously in respect to sudden electric impulses. The gas does not seem to possess any appreciable inertia to such impulses, for it is a fact, that the higher the frequency of the impulses, with the greater freedom does the discharge pass through the gas. If the gas possesses no inertia then it cannot vibrate, for some inertia is necessary for the free vibration. I conclude from this that if a lightning discharge occurs between two clouds, there can be no oscillation, such as would be expected, considering the capacity of the clouds. But if the lightning discharge strike the earth, there is always vibration —in the earth, but not in the cloud. In a gas discharge each atom vibrates at its own rate, but there is no vibration of the conducting gaseous mass as a whole. This is an important consideration in the great problem of producing light economically, for it teaches us that to reach this result we must use impulses of very high frequency and necessarily also of high potential. It is a fact that oxygen produces a more intense light in a tube. Is it because oxygen atoms possess some inertia and the vibration does not die out instantly? But then nitrogen should be as good, and chlorine and vapors of many other bodies much better than oxygen, unless the magnetic properties of the latter enter prominently into play. Or, is the process in the tube of an electrolytic nature? Many observations certainly speak for it, the most important being, that matter is always carried away from the electrodes and the vacuum in a bulb cannot be permanently maintained. If such process takes places in reality, then again must we take refuge to high frequencies, for with such, electrolytic action should be reduced to a minimum, if not rendered entirely impossible. It is an undeniable fact that with very high frequencies, provided the impulses be of a harmonic nature, like those obtained from an alternator, there is less deterioration and the vacua are more permanent. With disruptive discharge coils there are sudden rises of potential and the vacua are more quickly impaired, for the electrodes are deteriorated in a very short time. It was observed in some large tubes, which were provided with heavy carbon blocks B B_1, connected to platinum wires w w_1 (as illustrated in Fig. 33), and which were employed in ex-

periments with the disruptive discharge instead of the ordinary air gap, that the carbon particles under the action of the powerful magnetic field in which the tube was placed, were deposited in regular fine lines in the middle of the tube as illustrated. These lines were attributed to the deflection or distortion of the discharge by the magnetic field, but why the deposit occurred principally where the field was most intense did not appear quite clear. A fact of interest, likewise noted, was that the presence of a strong magnetic field increases the deterioration of the electrodes, probably by reason of the rapid interruptions it produces, whereby there is actually a higher E. M. F. maintained between the electrodes.

Much would remain to be said about the luminous effects produced in gases at low or ordinary pressures. With the present experiences before us we cannot say that the essential nature of these charming phenomena is sufficiently known. But investigations in this direction are being pushed with exceptional ardor. Every line of scientific pursuit has its fascinations, but electrical investigation appears to possess a peculiar attraction, for there is no experiment or observation of any kind in the domain of this wonderful science which would not forcibly appeal to us. Yet to me it seems, that of all the many marvelous things we observe, a vacuum tube, excited by an electric impulse from a distant source, bursting forth out of the darkness and illuminating the room with its beautiful light, is as lovely a phenomenon as can greet our eyes. More interesting still it appears when, reducing the fundamental discharges across the gap to a very small number and waving the tube about we produce all kinds of designs in luminous lines. So, by way of amusement, I take a straight long tube, or a square one, or a square attached to a straight tube, and by whirling them about in the hand, I imitate the spokes of a wheel, a Gramme winding, a drum winding, an alternate current motor winding, etc. (Fig. 34). Viewed from a distance the effect is weak and much of its beauty is lost, but being near or holding the tube in the hand, one cannot resist its charm.

In presenting these insignificant results I have not attempted to arrange and co-ordinate them, as would be proper in a strictly scientific investigation, in which every succeeding result should be a logical sequence of the preceding, so that it might be guessed in advance by the careful reader or attentive listener. I have preferred to concentrate my energies chiefly upon advancing novel facts or ideas which might serve as suggestions to others, and this may serve as an excuse for the lack of harmony. The explanations of the phenomena have been given in good faith and in the spirit of a student prepared to find that they admit of a better interpretation. There can be no great harm in a student taking an erroneous view, but when great minds err, the world must dearly pay for their mistakes.

THE ELECTRICAL WORLD'S DIGEST
OF
CURRENT TECHNICAL ELECTRICAL LITERATURE.

(Compiled from the principal foreign electrical journals.)

BY CARL HERING.

ELECTROPHYSICS.

Hall's Effect.—Prof. Kundt is undertaking the study of this phenomenon; according to the London "Elect. Rev." his plan is to prepare translucent metallic films, observing the magnetization by the rotary power on polarized light; in many cases he finds that the effect increases directly with the magnetization.

The "Elek. Zeitschrift," May 5, contains an abstract of a paper by Mr. Lommel showing how the Hall effect may be demonstrated by photographing the equi-potential lines; he also gives an explanation of the phenomenon and a formula for calculating the E. M. F. generated.

MAGNETISM.

Magnetization Curves.—See Mr. Dallas' article under Dynamos.

UNITS, MEASUREMENTS, INSTRUMENTS.

Electric Nomenclature (Congress Proposals).—Mr. Hospitalier, in "L'Ind. Elec.," May 10, has another short article on this subject, which is intended to form part of the discussion on the proposals for the Chicago Congress. The article includes the table of symbols, etc., which was reprinted in the May number of the "Trans. of the Amer. Inst. of Elec. Eng.," page 295, in the form of an appendix to the report of Institute's Sub-Committee on Provisional Programme. It differs from this in that five new physical quantities, to be mentioned below, have been added; the quantity "difference of potential" has been omitted and the quantity "specific conductivity" (Fr. conductibilité) has been given the symbol γ. He proposes to add the quantity "volumetric energy," derived from the quantities which make up its name, namely, "work" divided by "volume;" it has the same dimension as pressure, and could be represented by the symbol p; the C. G. S. unit is an erg per cubic centimetre. To the magnetic units and quantities he proposes to add "specific magnetism," defined as the quotient of the magnetic moment of a magnet by its mass; if the practical usage warrants it this quantity might be given a special symbol. In order to correspond with the terms "reluctance" and "reluctivity," the words "permeance" (corresponding to "conductance") and "permeability" ought to be adopted, and he does not think it at all necessary to change the latter into "inductivity." Permeance is the reciprocal of resistance (he doubtless means the reciprocal of reluctance), and reluctivity the reciprocal of permeability. In accordance with the propositions of Mr. Guillaume, he advocates the systematic adoption of the termination "ance" for physical magnitudes, which are independent of the properties of the material and vary with the mass or the dimensions, and reserve the termination "ity" for the properties of the materials; specific resistance then becomes "resistivity," "conductivity" (Fr. conductibilité), the reciprocal of resistance becomes "conductance," and what is termed "specific conductivity" becomes simply "conductivity." Following this strictly the name "capacity" ought to be applied to what is now called the "dielectric-constant," "inductive capacity" or "specific inductive capacity," and the true capacity would have the name "capacitance;" notwithstanding that this would be more logical, he fears it would be too great a change in a term already universlaly adopted. He proposes the term "linear capacity" for the quotient of the capacity of a wire by its length and measured in microfarads per kilometre; "linear insulation," the product of the insulation resistance of a wire by its length; "linear resistance," the quotient of its resistance by its length. The expressions heretofore used, namely, kilometric capacity, kilometric insulation, etc, are not rational, as they introduce a unit into the definition of a physical magnitude which destroys the homogeneity of the definition, as it compels one to change it in changing the units. He puts great stress on the fact that definitions of physical quantities are and ought to be independent of units of measurements. (This seems quite rational and ought to be adhered to, although it will doubtless be difficult to adopt this rule universally) He proposes to reserve the name of "coefficient of self-induction" for the quantity (of the same dimension as a length) defined as the quotient of a flux by the intensity of the current which it produces. Special names might be used to designate the secondary phenomena resulting from the variation of the magnetic permeability, and in which the quantities which enter are of the same dimension as the co efficient of self-induction; in this connection he refers to the discussion of Messrs. Blondel and Boucherot (see Digest May 20 and April 15). In view of the difficulty of formulating a system of practical magnetic units which are coherent and uniform, he thinks it advisable to use other units than the C. G S. magnetic units, and he therefore suggests giving these units special names in preference to adopting the practical units proposed by the Institute. It would be advisable to adopt a special word to designate the factor $\omega = \frac{2\pi}{T}$ equal to 2π times the frequence and which Dr. Fleming calls "pulsation" (see The Alternating Current Transformer, Vol. I., page 105); he suggests that the Congress sanction this name. If a periodic E. M. F. exists in a circuit consisting of a resistance R, a self-induction L and a capacity K, the effective intensity of the current is equal to the quotient of the effective E. M. F. by a factor called "impedance." In designating 2π times the frequency (that is the pulsation) by ω the general relation will be

$$C_{eff} = \frac{E_{eff}}{\sqrt{R^2 + \left(\omega L - \frac{1}{\omega k}\right)^2}}$$

The impedance is the radical in this exception. He proposes to give the name "reactance" to the factor in parentheses and define it, as Mr. Boucherot does, as a quantity of the same dimensions as a resistance, which does not absorb energy and the square of which added to the square of the resistance gives the square of the impedance. The reactance due to self-induction is the product of the pulsation and the co-efficient of self induction; the reactance due to capacity is the reciprocal of the product of the pulsation and the capacity. If there are in the same circuit a self-induction and a capacity the total resistance is the difference of the two reactances (the reactance of a capacity is the reciprocal of its permitance according to Mr. Heaviside); the name "reactance" has the advantage over the name "inductance," as it admits of more general application to the actions of inductance and capacity. He does not see the necessity of adopting the expression "impressed E. M. F.," defined as the ratio of the total activity in a circuit to its instantaneous current strength. Regarding polyphase currents he states that the definitions proposed by the American Institute of Electrical Engineers lack exactness and ought to be modified; an alternating current for instance passes in a single period through all the phases of which it is susceptible and an ordinary alternator, the current from which flows through circuits having different reactances, produces several currents of which the phases are not in accord. The difference in the phases of di-phase or tri-phase currents cannot be expressed in degrees, but in fractions of a period; the expression "polyphase" should be applied not only to more than three currents but also to di-phase and tri-phase currents. He thinks the subject of photometry is not yet sufficiently advanced to formulate propositions.

Practical Problems at Chicago.—Prof. S. P. Thompson's article on this subject is concluded in the "Elec. Eng." May 12. In it he discusses the present practice and future possibilities. His suggestions refer more to the papers and the discussions which are to be expected, instead of to the actual work to be done at the Congress.

Wattmeter.—In the "Elek. Zeitschrift," April 21, Mr. Friese concludes his article on his new wattmeter, mentioned in the Digest May 6. He gives considerable data regarding its constants and its errors; he describes its use as a dynamometer and as a wattmeter for measuring strong alternating currents, in which case the series coil is used as a shunt to a known resistance; in the latter case he shows that the time constant of the shunt must be equal to that of the closed circuit formed by the shunt and the series coil. This instrument seems to have a number of points of merit.

Oulton-Edmondson Meter.—The Lond. "Elec. Eng.," May 12, describes and illustrates this meter, which belongs to the double pendulum type. The synchronism is said to be perfect, the reading is proportional throughout any range and the pendulums are driven without clockwork, a small impulse arm being lifted by an electromagnet at each double vibration; the two pendulums are suspended from one bar, which is itself suspended by stiff springs by which means, according to a well known principle in physics, the vibrations of the pendulums are kept in unison as long as no current is consumed; the volt coil at the end of one pendulum vibrates within the fixed series coil; the current required to keep it in motion is .02 ampère; the pendulums do not move until the current is turned on.

Condensers at Low Temperature.—In a letter to the Lond. "Elec. Rev.," May 12, under the heading of "A Strange Phenomena," a correspondent states that at three degrees C. he found that a condenser gave a constant deflection (showing bad insulation), while at 14 degrees C. it was excellent. From this it appears that the condenser is useless at such low temperatures.

Differentinl Galvanometer.—Mr. Levy, in the "Elek. Zeitschrift," May 5, describes some new methods for using differential galvanometers, more particularly for the measurement of small resistances.

Starting Synchronous Motors.—Mr. Olivetti, in the Lond. "Elec. Rev.," May 12, describes the following method: Short circuit the brushes; divide the main current (for the field) into two branches, one containing a condenser and the other a self-induction; if suitably calculated, the difference of phase in these two will be about 90 degrees; each of these two circuits is made to excite alternate poles of the field; the speed of the rotary field produced is double that of the normal speed of the armature; the connections are shown in two cuts, the divided current being produced by a transformer having two separate secondaries; by means of a switch the change of connections can readily be made, the change consisting in throwing off the transformer, throwing the armature on to the line, and the exciter on to the field; the switch may be operated automatically by a relay governed by a centrifugal governor. The above applies when the number of poles is a multiple of four; if it is a multiple of six, the current must be divided into three branches, differing by 60 degrees.

Motor.—The Lond. "Elec. Rev.," May 12, illustrates a small domestic motor having a few points of interest from a constructor's standpoint.

Brushes.—The present installment of Mr. Guy's serial, in the Lond. "Elec. Eng.," May 12, is devoted to the subject of brushes and sparking.

ARC AND INCANDESCENT LIGHTS.

Small Arc Lamps v. Incandescent Gas Lamps.—In the "Elek. Zeitschrift," April 21, Dr. Heim adds a correction to his article abstracted in these columns April 29. His correction has reference to the spherical intensity; he gives corrected tables and data, and finds that after making this correction the cost of gas incandescent light is 87 per cent. of that over small arc lamps.

Fuerstenfeld-Bruck Central Station.—The "Elek. Zeitschrift," April 21. gives a full, well illustrated (17 cuts) description of this installation. It is of interest as an economica. station for a small town; alternating currents are used, and are generated at a distant station by means of water power.

Hull Station.—The Lond. "Elec. Rev.," May 12, describes this accumulator station accompanied by four large views and a number of small cuts; it includes a table of costs of station and main. One of the interesting features is the undergrounnd conductors (see under Wires and Conduits.)

Pumping Plant.—The English journals contain a description of a small pumping plant recently erected; the generator and motor are both series wouud; it contains little of novelty.

WIRES, WIRING AND CONDUITS.

Underground Conductors.—The description of the Hull (England) station in the Lond. "Elec. Rev.," May 12, includes a description of a system of underground conductors; it consists of bare copper wires stretched and suspended in shallow earthenware ducts under the sidewalks; tubular insulators are used for the end pieces which take up the strain, enabling the copper conductors to be held nearer the roofs of the culverts than in the original Crompton system, thereby permitting the straining parts to be farther apart or the culverts to be made more shallow. Owing to the vicinity of the gas pipes the culverts are ventilated by being covered with a perforated plate; the ducts are placed close to the walls of the houses; they are cleaned out once in three months. Good working drawings of these ducts are shown.

TELEGRAPHY, TELEPHONY.

Simultaneous Telephoning and Telegraphing.—A note in the "Elek. Zeitschrift," May 5, states that an invention of Mr. von Demetzky has recently been tried on a line 120 miles long with complete success. The apparatus is very simple and can be connected to any telephone line; disturbing causes are thereby also avoided. On short lines the telephone receiver is so loud that speech can be distinctly understood by several persons in the room. No description is given.

The General Electric New Street Railway Motor.

The efforts of street railway electrical engineers have been, for some time past, concentrated on the improvement of the street railway motor, and particular attention has been paid to the reduction of the weight of the motor itself, on account of the influence which this item alone has upon the amount of money expended upon keeping the tracks in good repair.

From the four-pole motor of new design, known as G. E. 800, which the General Electric Company has just put out, the shortcomings which have characterized all other motors, and which have been rendered evident under actual working conditions, have been eliminated or greatly modified.

The nomenclature of 800 has been given to this motor, as indicating its ability to exert a horizontal effort of 800 pounds through a 33-inch wheel continuously in ordinary street railway service. This rating is more accurate than that customarily employed, and adopting the General Electric Company's usual conservative method of rating in horse power the motor becomes a 25 h. p. motor.

The question of preservation of tracks is one of deep importance to every operating electrical street railway company. The extent to which it usually figures on the balance sheet haa shown that errors must no longer be made, and has created a demand for a motor light enough to reduce the wear and tear of track to a minimum. The motor

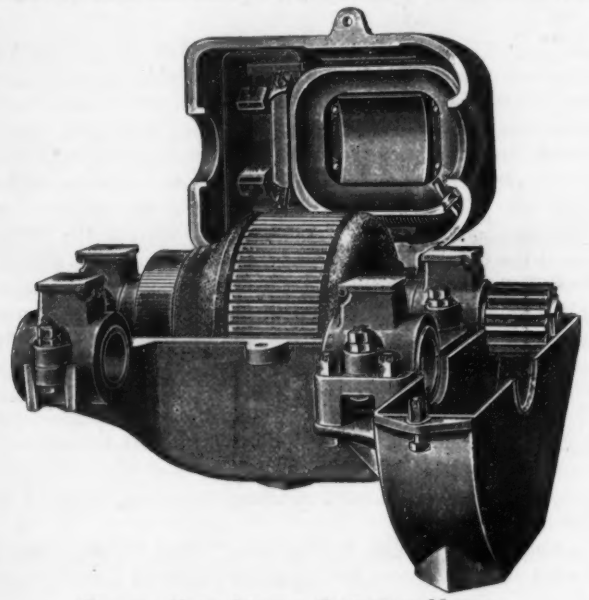


Fig. 1.—New Street Railway Motor.

in question is even lighter than the 15 h. p. motor formerly sold by the General Electric Company. It is not less than 660 pounds lighter than the old S. R. G. 15 h. p. motor, and some two or three hundred pounds, lighter than the W. P. 15 h. p.

In suspending this motor on the cross frame of the truck, it will be so hung that only 500 pounds of its weight will bear directly on the axle. From this it will readily be seen that the dead blow delivered from the axle to the truck is enormously reduced, when comparison is made with the work of other motors.

Working parts are more easily accessible even than in the well known W. P. motors. The aperture necessary for the purpose of inspection, cleaning, etc., is so designed that when closed those parts which could be damaged by water —the brushholders, commutator, armature and field spools— are so entirely inclosed in a watertight box that the entire motor could be immersed in water and still operate as under normal conditions. This renders the motor of equal value in either summer or winter service, in either bad or good weather.

This closing of the motor so as to make it water and dust proof has been rendered possible by its superior design and the liberal use of copper and the best grade of steel in its construction, whereby the heat generated in the motor has been materially reduced. The motor, even closed up as it is, runs much cooler than previous motors that were entirely exposed. It can be taken apart with the utmost facility. The top frame is hinged on to the lower frame, and with its proper parts weighs only 350 pounds. On the removal of only two bolts it can be thrown back completely out of the way of the armature, or by the removal of the hinge pins the top frame can be lifted into the car, or by moving the nose plate forward the motor can be swung upon the ring axle as a hinge, so as to be accessible from the pit, the top field then being swung on its hinges still lower into the pit, in which position the armature and field spools can be easily removed; or by the removal of the top of the gear case and two axle caps the motor can be lowered as a whole into the pit. The armature is short and can be lifted

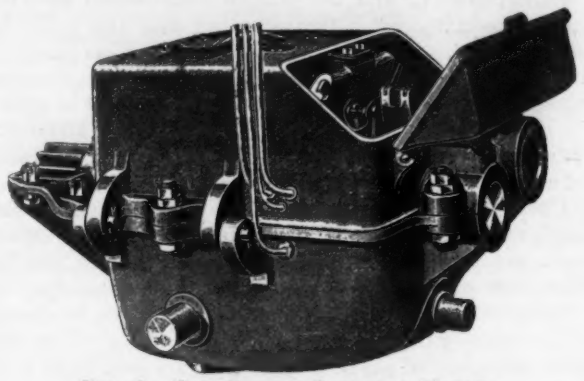


Fig. 2.—New Street Railway Motor.

through an ordinary trap door. It will thus be seen that the motor can be handled either inside the car or from without with almost equal facility. On opening the lid over the commutator easy access is had to the whole width of the commutator and brush holders, the latter being of the simplest possible construction and easily operated with one hand. There is also plenty of space to permit of the pit of the motor being reached. The bottom of the armature is two inches above the pit of the motor, so that it is not liable to be injured by articles falling inside of the motor frame. The construction is such that it is practically impossible for any grease to get inside of the motor at present.

The armature is similar to that used on the well known W. P. motors and is made both in the Gramme ring armature and in the drum form. A thorough trial has demonstrated that the drum winding of this motor, which has been carefully studied, can be relied upon. It will be free from the danger of burning out at the ends, heretofore common with this kind of winding. The Gramme armature and drum armature are interchangeable.

No point of fault which motors of all makes have manifested has passed unstudied, and in the motor under consideration the General Electric Company believes that it has been able to do away not only with the ordinary defects, but also those which only declare themselves under certain contrary and extraordinary conditions. The electrical qualities of the machine have been subject to several months of stringent test under actual service conditions, with most successful results,

Protective Fuses of Precision.

Protecting fuses for a long period of time in all shapes, sizes and carrying capacities have been in vogue, but the unfortunate circumstance connected with them is that while they protect sufficiently or practically well the coarser electrical apparatus, where an excess of 100 per cent. in the intended point of fusing of the fuse is of comparatively little importance, yet when it is sought to protect high resistance apparatus of low-carrying capacity, in which an excess of 10 or 20 per cent. in the current beyond that which the instrument is normally built to carry, a laggard fuse results in dire destruction.

The "W. B. G. Accurate Fuse Protector" which is placed on the market by The E. S. Greeley & Co., 7 Dey street, New York City, is, as is generally understood by the electrical public, and as is well known in the telephone service, where the device is largely employed to advantage, a union of the ordinary fusible wire fuse and a heat coil. The fusible wire itself is selected with the greatest possible care as to reliable fusing point, and the heat coil, consisting of an insulated German silver wire, is wound around one extremity of the same, where it performs the double office of insulating, the fuse wire itself from variations in external or atmospheric temperature and concentrating upon the wire accumulatively, if it may be so stated, the internal or electric heat. Now when the fuse wire itself is carefully selected and temperature variations impeded by the surrounding coil, and the coil itself is properly adjusted in resistance and convolutions, the effect is to obtain a calibrated fuse of precision that responds faithfully to the thermo-electric conditions, and fuses accurately at any predetermined capacity, graded in tenths of an ampere, from two-tenths ampere upward.

TWO-WIRE W. B. G. FUSE PROTECTOR.

These fuses are now largely used for the protection of magnets in telephone service and other apparatus having a resistance of 600 ohms and over, and are claimed to be thoroughly reliable in their protective work.

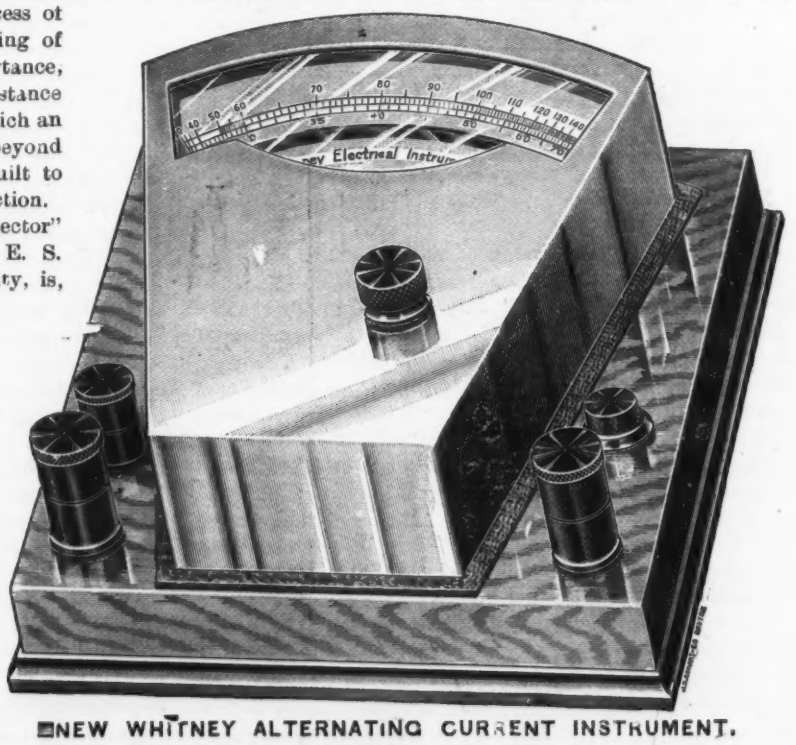
The Graphite Arc Destroying Fuse Protector is one in which the heat coil is not present, and therefore the same accuracy or precision of operation is not attained, but it has the valuable feature in event of the opening of the fuse being followed by an arc of destroying the arc instantly. It consists of a small rod of very fine and uniformly compressed graphite an inch or so in length and smaller in diameter than a lead pencil, mounted at each end with a metal cap to secure perfect connection, proper terminal facilities and a place for the deposit of a small portion of fulminate of mercury, which is lodged in one of the caps. The continuity of the circuit is dependent upon a fraction of fusible metal attached to or close by the charged cap, so that if upon fusing of the metal there should be any following arc whatever, the fulminate is discharged and the arc blown out.

The W. B. G. Protector has been utilized to the effect that it is apt to open under discharges of lightning that might be harmless to the instrument under protection, and renders the renewal of the fuse necessary. It is never charged that the W. B. G. Protector fails to protect in all cases where it is desirable to do so, but owing to its delicate organization it sometimes, as is above shown, answers to a high E. M. F. with low amperage that would have no destructive effect. A joint use of the W. B. G. Protector and the Graphite Arc Destroying Fuse Protector should be adopted, as the Graphite Protector is not sensible to the lightning discharges, and if it is connected into the line ahead of the W. B. G. Protector, by proper provision being made for escape of the lightning to ground from the graphite, a protection against foreign and destructive currents of all kinds is claimed to be obtained.

The New Whitney Alternating Current Instruments.

In the accompanying illustration is shown one of the new Whitney instruments for alternating current work. The alternating current voltmeter is an excellent piece of work, with a scale guaranteed almost absolutely accurate and with which the most careful measurements of any alternating currents without being affected, it is claimed, by any variations in frequency. This has always been a great difficulty, and has necessitated recalibration of each instrument for the particular machine on which it was to be used, whereas the Weston instruments can be used on any kind of alternating current machines.

The uniform divisions of the scale is another point to which particular attention is called. Improvements in this respect are being continually made, and the voltmeter scales as now divided are even more uniform than shown in the accompanying cut. The 0 to 75 scales read from 15 to 20 in one-volt divisions, and from 20 to 75 in half-divisions. The 0 to 150 scales read from 30 to 40 in two-volt divisions, and from 40 to 150 in one-volt divisions. The double scale instrument combines both of the above scales and reads in the same way.



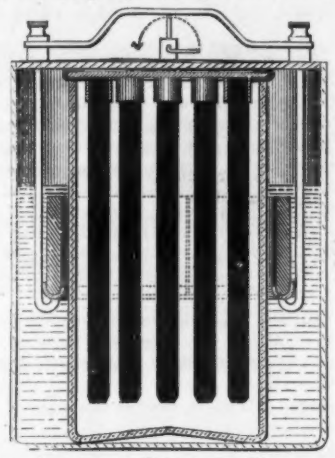
NEW WHITNEY ALTERNATING CURRENT INSTRUMENT.

Heretofore it has been found necessary to use a dynamometer requiring elaborate manipulation and considerable mathematical computation, and the Whitney company claim to have produced an ammeter which is both portable and accurate. In the smaller sizes it reaches as low as $\frac{1}{10}$ of an ampere, with correspondingly small division for the larger capacities.

The Electric Appliance Company, of Chicago, is the general Western agent for the Whitney instruments. These instruments have been received with favor, and it is claimed that they have operated with very satisfactory results. A portable, reliable instrument that can be used on any ordinary alternating current circuit will no doubt meet with success.

The Atlantic Primary Battery.

This new battery, which is placed on the market by the Electro-Chemical and Specialty Company, 136 Liberty Street, New York, consists of an India rubber cell 6½ × 7 × 8 inches high, with tightly fitting cover, 18 carbon pencils,



THE ATLANTIC PRIMARY BATTERY.

a porous cup, a zinc element, connection screws and the arrangement to raise the zinc out of the solution by a handle on the cover, without lifting the latter or disconnecting the wires when the battery is not in operation. Any two fluid carbon battery solutions can be used.

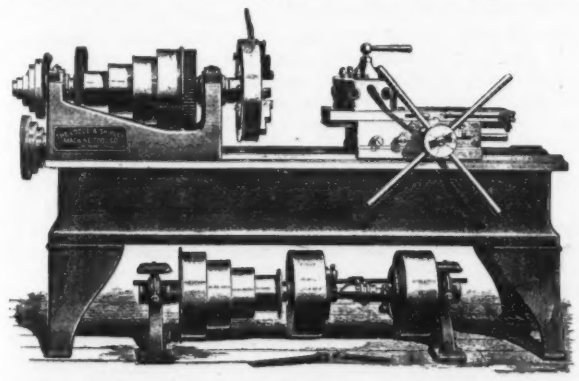
It is so constructed that the connections will not corrode, and there is no change in internal resistance. It will maintain constant E. M. F. during the life of the charge, and there is no consumption of zinc while the battery is not in operation.

The battery shows on short circuits, when fully charged, it is claimed, 40 ampères and two volts, and has a capacity of 150 ampère-hours.

It is well constructed, neat, compact, highly efficient and economical, and is specially adapted for medical purposes to run fan motors, sewing and dental machinery, phonographs, etc.

The Lodge & Shipley Turret Chucking Lathe.

A 22 inch turret chucking lathe, manufactured by the Lodge & Shipley Machine Tool Company, of Cincinnati, O., is shown in the accompanying illustration. The advantages of such a tool are well known, and the manufacturers have endeavored to embody in this machine all the valuable features of those already in the market. This lathe swings 22 inches, has 7-foot bed, and is back-geared; it is driven by a 4-step cone for a 4-inch belt. The spindle is crucible steel. Front bearing, 3¾ × 5½ inches; back bearing, 3½ × 4 inches. The bearings are phosphor-bronze. Turret is 13 inches in diameter, and is made to revolve automatically or by hand. When made to revolve automatically a lever is provided to withdraw the locking pin by hand, so that turret may be revolved at any point of its



THE LODGE & SHIPLEY TURRET CHUCKING LATHE.

stroke. This avoids having to move the slide back to a given point, and permits of using one, two or any number of tools, and moving them backward or forward as the nature of work may require. It is provided with four changes for power feed, and an adjustable automatic stop for same. A pilot wheel is used for hand movement. The feed is particularly powerful and substantial. It is provided with friction countershaft with back and forward movement and pulleys 14 inches in diameter, 5-inch face, which should run 130 revolutions per minute.

This company also manufactures an 18-inch four-jaw combination chuck with reversible jaws, which is really a 24-inch chuck in all its mechanism except its diameter. It is furnished with a wrench 15 inches long, which will grip with all the power of a 24-inch chuck, and its wearing qualities are much enhanced; its weight is 3,000 pounds.

Electric Lighting in Japan.

Considerable progress is now being made in the matter of electric lighting in Japan. Three new central stations, located respectively at Hamamatsu, Maibashi and Nikko, will be opened in June or July. The power in each case will be furnished by Pelton water wheels, which will drive 2,000-volt alternating current dynamos. The entire equipment will be constructed in Japan, even to the incandescent lamps. Nikko is a famous summer resort; all three of the cities are small and do not require more than 500 or to 1,000 incandescent lamps each.

Financial Intelligence.

THE ELECTRICAL STOCK MARKET.

[Inquiries from our patrons for information relative to stocks and bonds of the various electric light and power companies are solicited, and will be answered in this column.]

NEW YORK, May 22, 1893.

GENERAL FINANCIAL STOCK MARKET.

The transfer of 15,000 shares of an electrical stock in one block was the chief event of a week otherwise characterized by dullness and inactivity. Transactions with one notable exception have been few and quotations have fluctuated but little both in listed and unlisted electrical securities. The general tendency of the market was bearish and trading confined mostly to the exchange manipulators. There is said to be a large short interest in industrials which forces quotations above their present natural basis, and thus electrical stock figures fluctuate occasionally without any regard to their real value. A few investors taking advantage of low prices have been heavy buyers, but there has also been much unloading, due to the universal need of cash. The dearth of ready money is partly caused by the inability of the banks to meet the urgent applications of would-be borrowers in the financial and mercantile community. It is evident that manufacturers and business men are now affected by the present financial tightness, which was felt so severely in Wall street three weeks ago. It is the impression in the street that gold shipments will cease with the exportation of $2,000,000 on Saturday. If this should prove true the prospects would be much improved for better money conditions.

General Electric stock has had another off week, having lost about all it had gained the week previous. The principal cause of the turn was the sale of 15,000 shares of New York Edison Electric Illuminating stock, valued at $1,500,000. This stock was considered one of the most valuable assets of the General Electric Company, and the ready reason given for parting with it is the need of cash. The disclosure of such affairs has a detrimental effect upon the stock, and again circulated rumors of weak financial conditions in the trust. Whether there is weakness or not, it is certain that the General Electric people have simply done what many others have also had to do in order to raise money. The exigencies of the times make such an action necessary. It is said the General Electric will still continue to receive a royalty for use of patents from the Illuminating Company. The General Electric Company have also disposed of 4,000 shares Boston Illuminating stock at $125 a share. The General Electric officials state that they have vast orders on hand for their motors and electrical appliances, and this may somewhat offset the sale of valuable assets. The Boston News Bureau states that a recent estimate of General Electric assets, wherein they were considered conservatively, item by item, showed that the Genera Electric Company could liquidate, go out of business, pay all its debts and still have $75 per share in cash left for the common stock.

The Edison Electric Illuminating Company of New York.—From May 15 to June 15, both inclusive the $3,260,000 5 per cent. debenture bonds of the Edison Electric Illuminating Company, of New York, are convertible into 6 per cent. stock, share for share. About 25 per cent. of the total issue has already been deposited. The authority under which the change is made gives the company the right, after 75 per cent. of the total issue has been deposited, to call in the remainder. Every indication now points to an assent of at least 75 per cent., and if this is secured the management will exercise its option. Quite a large number of these bonds, are held abroad, and for this reason they are slow in assenting. We have frequently commented upon the great real worth of this stock and recent events seem to well exemplify this statement. European investors are known to be pretty conservative, and when a syndicate of them purchase through a New York banking house a block of stock valued at $1,500,000 it speaks well for the security. Kuhn, Loeb & Co., the firm operating for the syndicate, made a very remunerative turn by the transaction, as the stock was purchased at 105, which was five points below the market price at the day of sale. New York Illuminating stock was quoted as high as 130 a few months ago and the only cause that can be given for its present depreciation is the existing financial situation. The stock's intrinsic value is undoubtedly much higher than present figures yet, buyers of securities are so scarce that very few sales are now made of this stock upon the stock exchange.

The Edison Electric Illuminating Company of Boston stock recently sold by the General Electric Company was 5,000 shares at 125. It is paying 8 per cent. and earning 12 @ 15 per cent. upon more than $2,000,000 capital. There are besides 6 per cent. bonds on the property to the amount of $675,000.

The Edison Electric Illuminating Company of Brooklyn, recently increased its capital stock by $1,000,000, making it $2,500,000. Last year it paid 5 per cent. and earned 6½ per cent. Its property is bonded at $500,000 in 5 per cent. non-convertibles. From the present showing of the earnings it is believed that the company will earn 6 per cent. upon its entire stock and bond issue, aggregating $3,000,000. The stock is owned almost entirely in Brooklyn. During last month the company showed an increase in a number of its lights to 6,000.

The Electrical Construction and Supply Company have declared a quarterly dividend of 2 per cent. on their common and preferred stock.

The Detroit Electrical Works has issued a circular to its creditors requesting them to meet at its office, Campau Building, Detroit, on June 2, 1893, at 10 o'clock a. m. The circulor states that the chattel mortgage given to Mr, Hugh McMillan is in process of foreclosure by him, and that Mr. McMillan has made a provisional arrangement with responsible parties, which can be carried out with the prompt aid of creditors, and which promises ultimate payment in full. All creditors whose claims are undisputed will be given an opportunity to join in it, and, if the arrangement is consummated, he will waive any preference given him by his mortgage, and share with other creditors upon the same footing. Creditors are informed that it is necessary for them to act promptly or the advantageous opportunity will be lost. The committee of reorganization must, however, be gratified at results that have already occured in their efforts to start the factory again. It is reported from Boston that sufficient money has been raised to resume business.

National Electrical Manufacturing Company.—Ralph E. Rust was yesterday appointed receiver of all the property of the National Electric Manufacturing Company at Eau Claire, Wis The assets of the company appear to be about $560,000 and the indebtness about $400,000. The appointment was made by Judge Bailey. The company is one of the largest electrical manufacturing companies in the United States. The cause of the appointment owing to threatened suits arising out of the stringency of the ney market.

ELECTRICAL STOCKS.

	Par.	Bid.	Asked.
Brush Ill., New York	50	25	30
East River Electric Light	100	..	65
Electric Con. & Supply Co. pref.	15	15	16
" " " " " com	15	15	17⅛
Edison Electric Ill., New York	100	111	111¾
" " " 1sts	...	110½	111
*Edison Electric Ill., Brooklyn	100	105	108
" " " Boston	100	140	160
" " " Chicago	100	220	230
" " " Philadelphia	100	135	145
Edison Electric Light of Europe	..	2	6
" Bonds	..	80	85
" Ore Milling	..	5	12
Fort Wayne Electric	...	121½	125¾
General Electric Company	100	72¼	72
" " deb. 5's	..	91	91¼
Interior Conduit and Ins. Co	100	55	60
Mount Morris Electric	..	..	65
Westinghouse Consolidated	50	..	32
" " pfd	50	..	47

* Ex. div.

NEW INCORPORATIONS.

The Franklinville Electric Light Company, Franklinville, N. Y., capital stock $12,000, has been organized to generate electricity. W. N. Ferris, S. A. Spring and E. E McNall are the promoters.

The Wyoming Electric Light and Power Company, Peoria, Ill., capital stock $15,000, has been formed to operate an electric light plant. E. B. Hillman, H. T. Hays and L. B. Bradley are the incorporators.

The Nazareth Electric Light and Power Company, Nazareth, Pa., capital stock $10,000, has been formed. R. Jackson, Jr., Pen Argyl, A. E. Erdman and J. J. Heintzelman, of Nazareth are the incorporators.

The Spring Valley Electric Light Company, Peoria, Ill., capital stock $25,000, has been formed to maintain and operate an electric light plant, etc. The parties interested are E. B. Hillman, H. T. Hays and L. B. Bradley.

The Strowger Farm Motor Company, Chicago, Ill., capital stock $4,000,000, has been formed to manufacture and deal in electric motors for farming purposes, etc. W. S. Strowger, C. M. Ferree and A. L. Stone are the promoters.

The Western Electric Supply Company, Des Moines, Ia., capital stock $25,000, has been formed to manufacture and sell electrical supplies, etc. C. E. Hunn, E. S. Hunn, D. W. Evans, Des Moines, Ia.; Chas. Scodder and H. C. Coen, Chicago, Ill., are the promoters.

The Old York Road Passenger Railway Company, Philadelphia, Pa., capital stock $15,000, has been formed to construct and operate an electric railway in Philadelphia. McClellan Hersh, C. S. Ehiting and Nelson Sailer, of Philadelphia, are the interested parties.

The Beck-Watts Fixture Company, Des Moines, Ia., capital stock $25,000, has been formed to manufacture and sell electric and other fixtures. Wm. Watts, F. I. Watts, W. H. Beck, H. E. Coen, all of Chicago; C. E. Hunn, E. S. Hunn and D. W. Evans, all of Des Moines, are those interested.

The Winchester Electric Light Company, Winchester, Ill., capital stock $14,000, has been formed to establish and operate an electric light plant. Wm. Hainsfurther, Sol. Hainsfurther, Wm. Milhous, Chas. H. Condit and Wm. Neat.

The Electric Appliance Corporation, Burlington, Kan. has been formed to manufacture and sell electrical appliances, etc. The promoters are B. Harrington, Estella Wingren, Warren Harrington and E. F. Morton, all of Burlington, Kan.

The Manchester Electric Truck Company, Manchester, N. H., capital stock $600,000, has been formed to manufacture and sell electrical appliances, etc. A. Blood, C. T. Means, F. P. Carpenter, D. Cross and H. E. Loveren are interested.

The Huntington Electric Light, Heat and Power Company, Huntington, N. Y., capital stock $20,000, has been organized to produce and use electricity. W. Lindsay, W. H. Stoyle and C. E. Scudder, Huntington, are the promoters.

The Niagara Electric Company, Niagara Falls, N. Y., capital stock $20,000, has been formed to generate electricity for light, heat and power. The promoters are Samuel Ames, G. A. Krupp, Buffalo, and G. W. Daggett, Nunda, N. Y.

The American Railroad Improvement Company, Jersey City, N. J., capital stock $1,000,000, has been organized to operate electric and other railroads, etc. E. Davis, G. A. Beatey, Hyde Park; H. H. Ashley, Springfield, Mass.; T. McCoubray, Jersey City, N. J., and O. B. Goldsmith, New York.

The D'Unger Electrical Telephone Manufacturing Company, Chicago, Ill., capital stock $100,000, has been formed to manufacture telephones and electrical apparatus. J. F. Greene W. D. Johnston and H. S. Folger are the promoters.

The City Railway Company, Dayton, O., capital stock $1,500,000, has been incorporated to build and operate electric street railways. W. H. Simms, J. C. Pierce, E. J. Barney, C. B. Clegg, C. L Ferneding and D. B. Corwin are the promoters.

The Wallkill Valley Electric Light and Power Company, Walden, N. Y., capital stock $16,000, has been formed to generate and use electricity. N. J. Fowler, I. H. Loughran and J. L. Crawford, all of Walden, are the interested parties.

The Lackawanna Valley Electric Light and Power Company, Mayfield, Pa., capital stock $150,000, has been formed to furnish light, heat and power by electricity. C. H. Mullin, W. F. Sadler, Jr., and Thos. Grimwood are the promoters.

The Parkersburg & Oxford Electric Railway Company, Mifflintown, Pa., capital stock $100,000, has been formed to construct and operate an electric railway in Chester county. J. J. Patterson, W. S. North and L. Banks are the organizers.

The Wilkes-Barre & East Side Railway Company, Wilkes-Barre, Pa., capital stock $50,000, has been incorporated to construct and operate an electric railway in Wilkes-Barre. W. G. Eno, W. S. Biddle and G. R. Bedford are the promoters.

The Pine Bluff Water, Gas and Electric Light Company, capital stock $500,000, has been formed to construct electric light plants, etc. E. H. Caffin, Brooklyn; J. Stearns, J. W. Bett and Chas. A. Winter, New York City, are the promoters.

The Royal Arc Electric Company, U. S. A., Plainfield, N. J., capital stock $1,000,000, has been formed to manufacture and deal in electrical apparatus. L. E. Howard, G. H. Squires, Plainfield, and F. C. Marsh, Elizabeth, N. J., are the promoters.

The Suffolk Gas Company, Islip, N. Y., capital stock $200,000, has been incorporated to generate electricity for light, heat and power. B. I. H. Trask, I. L. Egbert, New York City, and C. A. Kutle, of Mt. Kisco, N. Y., are the interested parties.

The Arverne and Rockaway Beach Electric Company, Arverne-by-the-Sea, N. Y., capital stock $50,000, has been organized to supply electricity for light, heat and power. Remington Vernam, Florence C. Vernam and C. C. Vernam, of that town, are the promoters.

The Media, Middletown, Aston & Chester Electric Railway Company, Media, Pa., capital stock $30,000, has been organized to build and operate a railway in Delaware county. E. O. Price, S. D. Riddle and J. W. Robinson are the promoters.

The Edison Electric Light and Power Company, Meridian, Miss., capital stock $50,000, has been formed to conduct a general electric light and power business in that town. I. M. Schulhers, H. C. Gallagher and F. E Gallagher are the organizers

The Post-Glover Electric Company, Cincinnati, O., capital stock $50,000, has been formed to deal in and manufacture electrical and railway supplies, etc. S. W. Glover, Oliver Kinsey, G. N. Devon, F. D. Van Winkle and G. H. Jones are the promoters.

The Texas Electric Burglar and Fire Alarm Company, Corsicana, Tex., capital stock $30,000, has been formed to manufacture and sell electric burglar and fire alarms. A. C. Sloan, A. F. Wood, B. Zadek, and J. Schwart, of that town, are the parties interested.

The St. Joseph Traction and Lighting Company, St. Joseph, Mo., capital stock $1,700,000, has been formed for operating cars by cable, electricity, etc. S. S. Palmet, New York City; J. T Gardiner, Albany, N. Y., and J. R. Owens, St. Joseph, Mo., are the promoters.

The Hanover Light, Heat and Power Company, Hanover, Pa., capital stock $25,000, has been formed to supply light, heat and power by electricity. F. E. Bailey, Philadelphia; David Longenecker, Harrisburg, and John W. Mumper, Dillsburg, Pa., are the promoters.

Special Correspondence.

NEW YORK NOTES.

Office of The Electrical World,
167-176 Times Building, New York, May 27, 1893.

The Complete Electric Construction Company has moved from 10 Cortlandt street to 121 Liberty street.

The Long Island Traction Company, of Brooklyn, has secured possession, it is reported, of the Broadway Railroad Company's five lines in that city.

Mr. H. C. Nichols, of the Iona Manufacturing Company, Boston, was in the city several days this week calling on the trade. He reports business as being very good.

Ajax Van Nuis, left last week for Boston, from which place he will go to Chicago to superintend the finishing touches of his exhibit, which will include his Ajax switch and also his lightning arrester.

Wm. C. Callmann & Co., general agents for the Feldkamp electric ceiling fans and the Safety Electric Company's motors and dynamos, have moved their offices from 591 Broadway to 136 Libery street, New York.

Mr. Frank W. Harrington, of the New York Insulated Wire Company, who has been in charge of the company's Chicago office since November last, has returned to New York, as his many friends will be pleased to learn.

Mr. E. F Phillips, of the American Electrical Works, Providence, R. I., accompanied by Mr. C. R. Remington, was in the city on Tuesday of this week. Mr. Phillips states that work upon the new factory which the company is erecting is progressing rapdly and that business is first class.

The New York Electrical and Development Company, 25 William street, of which Mr. E. S. Boggs is general manager, reports large and increasing orders for its electric automatic gas or electric lighter. This company has recently added an experimental and repair department for all kinds of repair work on electrical apparatus, such as fan motors, dynamos, etc.

The New York Press Club will hold a special meeting on Friday, June 2nd, for the purpose of electing a first vice-president in place of Chas O'C. Hennessey, resigned, and two members of the Board of Trustees to fill vacancies caused by the resignation of Messrs. George F. Spinney and Herman Ridder. The polls will be open from 12 M. to 5 o'clock P. M. on the day mentioned. The regular monthly meeting of the Club will be held on Saturday, ne 3, at 3;30 P. M.

The Electric Selector and Signal Company, 45 Broadway, New York, has elected the following board of directors: Jennings S. Cox, John Dougherty, James Brown Potter, Charles F. Homer, James M. Townsend, Jr., Wm. E. Tillinghast, Thomas Sturgis, Wm. C. Lane, F. P. Voorhees, C. P. Mackie. The officers are as follows: Thomas Sturgis, president; Wm. C. Lane, first vice-president; C. P. MacKie, second vice-president and general manager; F. P. Voorhees, treasurer; James Brown Potter, secretary; S. S. Bogart, general agent.

The Union Electric Railway, of New York City, has completed a deal whereby it becomes the possessor of the entire lines of the Westchester Electric Company. The lines of the latter company, when completed, will operate from the Hudson River to Long Island Sound, through the city, while the Union road will extend its present system from Fordham, meeting and connecting with the newly acquired line at Woodlawn. It is stated that the Union company has acquired title to all of the lines operated in the lower part of this county, namely, the White Plains and Port Chester lines. The terms of the lease or sale of the Westchester Electric Company's lines, which include the Yonkers electric road, Mount Vernon and New Rochelle lines, cannot be learned. President Thomas E. Crimmins has appointed John J. Ryan, of New Rochelle superintendent of the consolidated lines. It is generally understood that John D. Crimmins is at the head of the consolidated company. The work of connecting the lines will be pushed to completion as soon as possible.

NEW ENGLAND NOTES.

Branch Office of The Electrical World,
Room 91, Hathaway Building, 620 Atlantic Ave.,
Boston, Mass., May 26, 1893.

The Holizer-Cabot Company, Boston, Mass., reports a very heavy business in the motor line, particularly fan motors.

Mr. Mills, representing the New York Carbon Works, was a recent caller at this office. He reports business as being exceedingly good through this section.

Wm. A. Rosenbaum, the well known electrical expert and patent solicitor, of New York, is paying a flying visit to the "Hub." He made this office a pleasant call.

Mr. C. P. Bodwell has resigned his position with the Schuyler Electric Company and accepted another with the Waring Electric Company, of Manchester, Conn.

T. W. Ness, the well known telephone manufacturer, of Montreal, is visiting Boston, investigating the telephone situation, and made a very pleasant call at this office.

A company has been formed to manufacture the Green stopper lamp, and several of the directors recently visited Windsor Locks, Conn, to see about locating a factory there.

The Eastern Electric Light and Storage Battery Company, of which Mr. Alfred C. Clark is manager, at Lowell, Mass., reports a large demand for the "Sorley" storage battery, especially for phonographs.

Municipal lighting was recently discussed before the Citizens' Trade Association, of Cambridge, Mass. Mr. J. Henry Russell, president of the Common Council, argued in favor of a municipal plant, and J. Q. A. Bennett, of the Cambridge Electric Light Company, took the other side

The Brown Electric Company, of Boston, has closed the contract for the electrical equipment of 12 miles for the Lancaster & Columbia Street Railway, 36 miles for the South Jersey Traction Company, and the extension of the Hartford & Wethersfield Electric Street Railway Company.

Enamelac is a new black paint which the Massachusetts Chemical Company, of Boston, is just placing on the market, intended for painting conduits, iron poles, batteries, etc. Its points of advantage are that it contains no rubber to rot out, is proof against action of acids, bad water, etc., it contains no poisonous and foul-smelling gases, gives a beautiful, hard, glossy surface, equal to Japan, and dries hard in one hour; is a great surface coverer, and is inexpensive. The material from which this "Enamelac" is manufactured is the product of a secret process. The motto of the company is suggestive: "None shall excel or undersell."

WESTERN NOTES.

Branch Office of The Electrical World,
936 Monadnock Building, Chicago, May 26, 1893.

The Ansonia Electric Company, formerly The Electrical Supply Company, recently secured an order for the entire equipment of the Columbia (Mo.) plant for Stanley transformers.

Oregon City, Ore., May 22, 1893.

The Tacoma Railway and Motor Company recently placed in operation a new 1¼-in. cable. The cable which it replaced lasted four months.

The Crouch Electric Supply Company, recently incorporated in Portland, Ore., will sell and manufacture electrical apparatus, including dynamos.

Manager A. C. Sands, of Tacoma, has recommended that the Sunset Telegraph and Telephone Company extend its telephone line from Cosmopolis, Wash., to Westport.

The Townsend Electric Light and Gas Company, Consolidated, of Port Townsend, Wash., has elected as officers: R. B. Albertson, of Seattle, president; J. R. Mason, secretary; John Lillie, manager; J. E. Cain, superintendent.

The Tacoma Light and Water Company's lighting and water plants will be transferred to the city of Tacoma probably not later than July 1, by which time it is expected that the issue of $2,150,000 of city bonds will have been completed.

The Sunbeam Incandescent Lamp Company, it is reported, have made an arrangement with the General Electric Company which relieves them from all liability for any claim or damage for past infringement, and also releases all parties who had purchased lamps from them, and allows them to sell such material and lamps as they have had on hand. It is understood that this does not refer to the New Sunbeam lamp.

The Portland General Electric Company has just established two additional circuits on its East Side line, which is operated from the Oregon city station. One of the new circuits will supply street lights in Sellwood and the other commercial lights in Albina, both places being districts within the city limits of Portland. The demand for lighting has increased of late, obliging the company to reinstall several old machines temporarily while awaiting the completion of its new dynamos.

CANADIAN NOTES.

Ottawa, May 25, 1893.

Ottawa, Ont.—Among the resolutions adopted by the Board of Trade this week was one favorable to an act for the inspection and measurement of electricity.

Hull, Que.—Negotiations have practically reached a conclusion for the extension of the Ottawa Electric Street Railway across the Ottawa River to the city of Hull.

London, Ont.—A movement is on foot to have the London & Port Stanley Railway operated by electricity. It is said that the cost to equip the road with locomotives, cars and other adjuncts to a steam service will be over $100,000.

Iroquois, Ont.—Last week P. Keefe's sash and blind factory was found to be on fire and completely destroyed. As it contained the electric light plant the town will be in darkness for some time. Loss from $6,000 to $10,000, covered by insurance.

Hamilton, Ont.—Hugh C. Baker, manager of the Ontario department of the Bell Telephone Company, says it has been decided to introduce the automatic system wherever it is in demand, and automatic switchboards will accordingly be put into the Hamilton office at once.

Amherstburg, Ont.—Secretary W. J. Pulling, representing the Sandwich, Windsor & Amherstburg Electric Railway, has signed an agreement submitted by the City Council of Windsor for the 20 years franchise. The company will pay $500 a year for the first 10 years of its franchise and $1,000 for the second 10, making a total of $15,000.

Berlin, Ont.—Letters patent have been issued by which the Berlin & Waterloo Street Railway Company has been authorized to construct, maintain and complete works for the production of electricity for the purposes of light, heat and power, and to operate the same so long as electricity shall be employed as the chief motive power on the railway of the said company.

Ottawa, Ont.—At the annual meeting of the Ottawa Electric Light Company on Wednesday the following officers were elected for the ensuing year: President, R. Blackburn; vice-president, Senator Clemow; secretary-treasurer, Alex. Spittal; directors: Messrs. Allan Gilmour, S. Howell, Robert Blackburn, T. C. Keefer, Senator Clemow, T. Patterson and George Hay.

Windsor, Ont.—Application has been made to the Ontario government for a charter giving power to construct, acquire and maintain street railways along such of the streets of Windsor, Walkerville and Sandwich West, in the county of Essex, as the council of each municipality may authorize, and over and upon lands purchased or leased by the company for that purpose. Total capital stock $250,000.

Ottawa, Ont.—The Chief Engineer of Canals for the Dominion Government says that experiments with an electric plant are being conducted at Beauharnois Canal, and should they prove that the lock gates can be worked successfully in that way, he will have electric appliances put in at the Canadian "Soo" Canal. The practical result of the test now being made at Beauharnois will not be known for about a month. Water power to generate the electricity will be obtained direct from the canal.

Toronto.—One of the largest suits in the courts last week was that brought by the Toronto & Mimico Electric Railway Company against the Reliance Company, of Waterford, for $50,000 damages alleged to have been sustained by them through the failure of the defendants to carry out their contract to supply the plaintiffs with an equipment for their road last summer. The defendants supplied an equipment, and the line was run for two months, but during that time and since it is said that the plant proved most defective and that the company lose not only in profit, but also from their capital of $70,000 lying idle, and from the damage which their reputation has sustained.

Peterboro, Ont.—The Canadian General Electric Company has just turned out its fourth locomotive for the new Vancouver Coal Company. It is of a type known as a four-pole, north, south and two intermediate poles, three-face Tesla alternator, and will develop an average speed of eight miles an hour on the grades of the mine, which are very irregular. The locomotive is designated a 40-ton locomotive, not that it weighs 40 tons, but that its capacity is equal to handling that load. The length of the locomotive, nearly 12 feet, was determined by the diameter of the shaft and cage at the mine, for it had to be lowered intact to its home at the bottom of the pit. The current is delivered at about 3,000 volts and reduced down to 50 volts at the locomotive.

Toronto, Ont.—A decision was given in Osgoode Hall on Saturday in a case which has a general interest. The city of St. Thomas passed a by-law granting to the Bell Telephone Company a monopoly of the streets for the purpose of that business for five years. Chief Justice Armour decided that this was contrary to the provisions of section 286 of the Municipal Act, 55 Victoria, chapter 42, which says that "No council shall have the power to give any person an exclusive right of exercising within the municipality any trade or calling, etc." Six weeks ago Ottawa made an agreement with the Bell Telephone Company whereby, in consideration of five per cent. of its receipts, the company was to have the exclusive right to place telephone poles in the streets. If the above decision is not reversed on appeal, Ottawa will lose the revenue of $1,500 per year.

ENGLISH NOTES.

(From Our Own Correspondent.)

London, May 3, 1893.

Obituary.—The death is announced of Mr. Walter Glover, head of the well known firm of Glover & Co., insulated wire manufacturers; also of Mr. F. Geraldy, a frequent contributor to *La Lumière Electrique*.

Municipal Telephony.—As I mentioned in a previous letter, the Glasgow Corporation has decided to inquire into the question of itself supplying Glasgow with an efficient telephone service. Last week in connection with an application of the National Telephone Company for permission to run underground wires, the Manchester Town Council decided to refer the matter to an expert, and it was pretty freely hinted that it would not be at all a bad thing for the Town Council itself to undertake the telephonic supply.

Failure of the Electric Light in the House of Commons.—While the House of Commons was engaged in a heated discussion on the Home Rule bill on Monday evening the electric light failed. The House itself is still largely illuminated by gas, so that the excited legislators were not left in darkness. The precincts of the House, corridors, lobbies, refreshment rooms, reporters' rooms were, however, without light for some fifteen minutes. This untoward occurrence was due to a fuse going owing to some defect in the interior wiring.

Overhead Wires.—The reasonable antipathy to overhead wires excited in this country occasionally leads our municipal counsellors to extremes. A few days ago an application was made to the Middlesborough Corporation for permission to run a wire across a street from one hotel to another. It was decided that this could not be allowed, and the Mayor made the following extraordinary statement. He had, he said, discussed the subject with an electrical engineer, who said that overhead wires were a grave danger and that "owing to the enormous current passing through them they were in the habit of breaking."

The Bessbrook-Newry Electric Railway.—This line, which may fairly be considered to be the pioneer working electric railway in the world, was the scene of a curious succession of accidents last Saturday. An engine and passenger car to which were attached several wagon loads of goods was proceeding toward Newry when one of the freight wagons overturned and fell down the embankment. A breakdown gang was soon upon the scene in a lorry, and on the return of the train it proceeded to push this lorry in front of it toward Bessbrook, but in a few minutes the lorry managed to get under the "loco," with the result that it threw both "loco" and car off the rails and caused a block of 24 hours.

The Telephones and Electric Traction.—In a provisional order recently granted in connection with the tramway system of Great Yarmouth, it is satisfactory to note that the one-sidedness of the telephone protection clause hitherto inserted in such enactments has been modified. Formerly the electric traction circuits were responsible for any disturbance caused to telephone circuits whether the latter were erected subsequently to the traction circuits or not. In the clause in question a qualifying sentence is added, providing that subsequently erected telephone circuits must be constructed at a reasonable distance from the traction conductors and with reasonable and proper precautions against interference from them.

Cheap Telegrams.—Notwithstanding the annual deficit of about one-third of a million which our telegraph administration distinguishes itself by making, partly owing to having been obliged to accede to the demand for cheap telegrams and other facilities, and partly owing to the unfair method of keeping the accounts as between it and the Post Office proper, the clamor for further telegraphic privileges continues. The Associated Chambers of Commerce of the United Kingdom recently memorialized, to no purpose, the Postmaster General, asking him to allow addresses to be sent free. When it is considered that telegraphic messages can now be sent at a halfpenny per word with a minimum of sixpence, it will seem as if the limit of cheapness had been reached.

City and Guilds of London Institute and the City Corporation.—At the annual meeting of the governors of the City Guilds of London Institute, Lord Selborne, in moving the adoption of the annual report, said that the maximum capacity of the Institute was rapidly being approached. At the Central Institution, the electrical department of which is presided over by Professor Ayrton, the students now number 199; at the Finsbury Technical College, presided over by Professor Silvanus Thompson, the students number 213. Lord Selborne then went on to refer to the taking of a step by the City Corporation, which has for some little time been threatened, the withdrawal of its pecuniary support from the Institute. This withdrawal is more morally significant than practically important, since the total sum contributed by the City Corporation in 15 years only amounts to £14,500, or less than £1,000 a year on the average. It is, however, a somewhat peculiar step to take at a moment when English municipalities are everywhere voting large sums of money for technical education purposes.

News of the Week.

THE ELECTRIC LIGHT.

Hillyard, Wash., proposes to have the electric light.

Whitehall, Ill., is making an effort to secure an electric light plant.

Effingham, Ill., has voted $16,000 to buy an electric light plant.

Adrian, Mich., has voted to issue bonds for an electric lighting system.

The Dallas (Ore.) electric light plant will be enlarged in the near future.

Zumbrota, Minn.—The town is agitating the electric lighting question.

Sheffield, Ill. is discussing the question of introducing the electric light.

Haverhill, Mass., is contemplating putting in a municipal electric plant.

Deshler, O.—The Council is considering the matter of electric street lighting.

Lawrence, Mass., is considering the project of erecting a municipal plant.

Madison, Me., has decided to raise $15,000 to pay for an electric light plant.

Fruitville, Cal.—Capitalists have made a proposition to erect an electric light plant.

The citizens of St. Genevieve, Mo., have raised $18,000 for an electric light plant.

Jamestown, N. Y.—The city voted to increase the capacity of the electric lighting plant.

Erie, Pa., is having a lively discussion over the question of a municipal electric light plant.

Northfield, Vt.—The village trustees will report May 16 on the proposed electric lighting plant.

Sayre, Bradford County, Pa.—The Electric Light and Power Company of Sayre has been formed.

Athens, Bradford County, Pa.—The Tioga Point Electric Light and Power Company has been formed.

Newton, N. J.—The Electric Light Committee is considering the question of lighting the streets by electricity.

Portland, Me.—S. D. Warren & Co. will build an electric power plant at the Lower Falls of the Presumpscott.

Havre De Grace, Md.—The Mayor and City Council are discussing the matter of a municipal electric light plant.

Valley City, N. D., is to have an electric lighting plant. A 12-year franchise has been granted to Amundson & Sandbeck.

Waterford, N. Y.—The Waterford *Advertiser* is urging the establishment of electric lighting, and asks that it be put to vote.

Mellette, S. Dak., is considering the proposition to introduce the electric light, the power to be derived from an artesian well.

Waukesha, Wis.—The Electric Light Company contemplates putting in a new dynamo to double the present capacity of the plant.

Decatur, Ill.—The Municipal Electric Light Company has been organized with $25,000 to transmit and sell electric light, heat and energy.

The Delaware Electric Light and Power Company has sold its Middletown plant to Wm. S. Heger, of Wilmington, for $2,610.

Uxbridge, Mass.—Selectmen have signed a contract with the Uxbridge & Northbridge Electric Company for three years for street lighting.

The Bethlehem Electric Light Company claims it is one of the ten successful light companies in Pennsylvania, the other 147 paying no dividends.

The New Richmond Electric Light and Power Company, of Hudson, Wis., has increased the maximum limit of capital stock from $10,000 to $15,000.

Easton, Pa.—Chairman Bachman, of the Department of Water and Light, states that a new dynamo will be purchased, as the three dynamos now in service are overtaxed.

Bradford, Pa.—The plant of the electric light and power company will be increased by the addition of a 200-h. p. engine, a 2,000 incandescent light machine and a 50 arc light machine.

Chas. H Fairfield, of Concord, N. H., has a scheme to supply that city with electric light from a power station at Sprague ville, and will be one of the bidders for the street lighting franchise.

The Woonsocket Electric Machine and Power Company, of Woonsocket, R. I., has been authorized to erect poles and furnish electric light and power in Bellingham and Franklin.

Middletown, Pa —A special meeting of Council is to be held to take action with regard to holding another election to vote on the proposed issue of $25,000 in bonds to pay for an electric light plant.

The Peoples' Electric Light and Power Company, Creston, Ia., has been awarded the contract for the city lighting for a term of five years. Thirty or more arc lights will be required.

The Snows Falls Manufacturing Company, of Snows Falls, Me., has been incorporated with a capital stock of $60,000, and will operate an electric light plant. John Stanley is president and Fred J. Wood is treasurer. It is expected to have the plant in running order by July 1.

Philadelphia, Pa.—Sealed proposals will be received to June 10, 1893, by the Committee on Temple for an electric lighting plant for the Temple Building (Masonic Temple), Philadelphia, Pa. Specifications and drawings will be delivered to bidders between the hours of 9 a. m. and 3 p. m., May 29, at the office of Dr. W. A. Drysdale, Hale Building, Philadelphia, Pa.

The Cleveland General Electric Company is constructing an enormous electric light and power plant, to cost $500,000, with a capacity for 100,000 incandescents, 2,000 arcs and 1,000 h. p. for power service. There will eventually be twelve vertical compound engines of 650 h. p. each. The three-wire underground system is to be used for the heart of the city and alternating and high tension direct currents for the suburbs.

Reading, O.—Sealed proposals will be received by the Board of Water Works and Electric Light Trustees of the village of Reading, Hamilton Co., O, until Monday, June 5, at the clerk's office, for one 50-arc light machine of 2,000 nominal candle power for street lighting, with all necessary wiring, poles and 50 arc lamps, all in complete running order; also 500 16-candle power dynamo pole line and station equipment, all to be according to plans and specifications now on file at the clerk's office.

THE ELECTRIC RAILWAY.

Hillyard, Wash., proposes to have an electric railway.

Wabash, Ind., is considering the subject of electric railways.

Geneva, N. Y., has granted a franchise for an electric railway.

Kalamazoo, Mich., capitalists are talking of building an electric line to Gull Lake.

The West End Road, of Malden, Mass., will petition for leave to operate its line by the trolley system.

Jackson, Miss., has granted a franchise to W. E. Hayne and others of New Orleans for an electric railway.

The Indianapolis & Martinsville, Ind., electric railway, will soon be ready to consider propositions.

Frankford, Pa.—The Frankford & Southwark company will soon select a site for its proposed power house.

The Chicago & St. Louis electric road has secured right of way through Fairbury, Ill., and the citizens of that town are raising $10,000 for the road.

The Passaic & Newark (N. J.) Electric Railway Company has applied for a franchise for its proposed road to run through Franklin Township.

Frederick, Md.—The Board of Aldermen have granted a franchise for the construction of an electric trolley system to extend to Middleton, eight miles away.

Elizabeth, N. J.—The city council has refused a franchise to the Elizabeth and Plainfield Street Railway Company, but they will again apply at a later meeting.

Newberry, Lycoming County, Pa.—A franchise has been granted to the Newberry Street Railway, and it will shortly apply to the council for right to lay tracks.

Syracuse, N. Y.—Louis Marshall, of Jenney, Marshall & Jenney, is attorney for E. W. Emmons, who is getting up a company to build an electric railway to Fayetteville.

The Common Council of Amsterdam, N. Y., has granted to the Amsterdam Street Railway Co. the right to build and operate a surface street railway by the use of electricity.

Elizabeth, N. J.—The Elizabeth & Plainfield Electric Railroad Company has applied for a franchise to the Council here, and should same be granted work will at once be begun.

Port Huron, Mich.—The City Electric Company has filed a chattel mortgage for $200,000 with the Union Trust Co. as security for money borrowed for rebuilding and equipping the line.

Towanda, Pa., capitalists and others are talking of building an electric railway, from Towanda to Burlington, Troy, Sylvania, Mainesburg and Wellesboro, a distance of about 50 miles.

Augusta, Me.—J. Manchester Haynes, of Augusta, Me., has returned from Europe, and it is stated that the work of construction on the electric road to connect Oldtown, Orono and Bangor will begin.

Omaha, Neb.—The East Omaha Street Railway Company, capital stock $1,000,000, has been formed to build a road to Council Bluffs. H. W. Yates and A. S. Potter, of Omaha, Neb., are interested in the scheme.

Jersey City, N. J.—The Board of Freeholders of Hudson County has granted a franchise to the Jersey City, Rutherford & Hoboken Electric Railway for an electric road here, to be in operation within two years.

Stowe, Vt., has accepted a proposition from the Mount Mansfield Electric Railway Company to connect the town by an electric railway with Waterbury, Morrisville or Hyde Park, and has donated $40,000 for the road.

New Utrecht, N. Y.—An injunction has been secured on behalf of the town of New Utrecht to prevent the Brooklyn, Bath Beach & West End Railway from erecting trolley poles and building an electric road in that town.

Burlington, Vt.—The Board of Aldermen has granted a franchise to the new street railway company which supersedes the old company, with a view to equipping the road electrically and making important additions.

The Pittsburgh, Greensburg & Latrobe electric road, now being considered, will be 40 miles long. It is proposed to connect it with Manor, Harrison City, Boquet, Delmont and Export by a branch 12 miles long.

Pittsfield, Mass.—The street railway company has added $40,000 to its capital stock, the roadbed will be greatly improved, new rails laid and new cars put in. It may also extend its line to Dalton, about five miles east of Pittsfield.

The Philadelphia & Allentown Trunk Electric Company has awarded a contract to Silverman & Stern, Philadelphia to build 17½ miles of railway between Allentown and Hellerton at $15,000 per mile, the road to be in running order by Sept. 15.

Dayton, O.—The Dayton City Railway Company has been incorporated with a capital stock of $1,500,000. Wm. H. Sims, H. Pierce, Eugene J. Barney, Chas. B. Clegg and others are interested. The present termini will be the Soldiers' Home and the east ends of Third, Fifth and Richmond streets.

Rochester, N. Y.—Articles of incorporation have been filed for the proposed Rochester & Irondequoit Electric Railway Company. J. N. Beckley, president of the Rochester Street Railway Company, and Fred W. Smith, of Rochester, are interested in this project. The company will be capitalized at $1,000,000.

The Dubuque Light and Traction Company, Dubuque, Ia., has been organized with a capital stock of $600,000. It is understood that the General Electric Company is behind the new organization, which has taken over the properties and business of the late Dubuque Street Railway and Power Company.

The U. S. Rapid Transit Construction Company, of Chicago, has been formed to deal in contracts, privileges and materials for the construction of rapid transit roads, but not to operate same. J. L. McKittrick and Amos C. Miller, of 518, 164 Dearborn street are interested. The capital stock is $1,000,000.

Salem and Canton, O., have granted a franchise to the Canton-Salem Electric Company for an electric railway to connect the two towns. The company will incidentally control the electric lighting plants at Canton, Salem, and other towns along the proposed line, which will connect with the Canfield-Youngstown electric road.

The Grand Rapids (Neb.) Transit, Light and Power Company has been incorporated with a capital stock of $250,000 by A. S. Vest and E. G. Stolley. The business of the company is to operate electric motor cars. The work of surveying a new line will be commenced at once, and the line is promised to be in running order by this fall.

The Monmouth County Seashore Electric Railway Company will start out with a paid-up capital of $1,500,000, and will begin work upon a road extending from Pleasure Bay, near Long Branch, to Point Pleasant, passing through Long Branch, West End, Elberon, Deal Beach, Look Arbor, North Asbury Park, Asbury Park, Ocean Grove, Key East, Belmar, Spring Lake, Como and Point Pleasant. J. C. Shafer, the president of the Seashore Electric Railway, of Asbury Park, and the owner of several large electric railways, is at the head of the new company. The overhead trolley system will be used. Three operating stations are to be created along the proposed route, besides the one at Asbury Park, which the new company will purchase. The overhead trolley system will be used.

MISCELLANEOUS NOTES.

Underground Ducts.—Companies have been formed in Syracuse and Utica, and application made for franchise for the purpose of constructing subways, ducts and conduits for the electric wires of those cities.

Electricity on the Canals.—Superintendent Hannan, of the State Department of Public Works, has issued an order providing that all parties desirous of experimenting with electricity or other power for propelling boats on the canals must have their applications for such privilege on file in his department by June 5.

Trade and Industrial Notes.

The Onondaga Dynamo Company, Syracuse, N. Y., has received a communication from Chas. B. Knox, of Johnstown, N. Y., stating that he had had no complaints from the engineers or from any part of his factory since the Onondaga dynamo has been installed, and was perfectly satisfied with its operation.

The La Roche Electric Works, 116-118 North Sixth street, Philadelphia, Pa., within the last three months has installed 15 of its direct current dynamos in Philadelphia and vicinity, which are spoken of in the highest terms. The La Roche company is now making arrangements for increasing its manufacturing capacity.

The Railway Equipment Company, Pullman Building, Chicago, Ill., has issued a new catalogue, which gives a very complete description of the electrical supplies for all systems which this company handles. The last portion of the pamphlet is given up to wiring tables and information on electric railways which will be of value to practical men, and an excellent index makes easy reference to any particular subject.

The Elliott Electric Company, Cleveland, O., is working night and day to fill its orders, and has taken a large frame building in the rear of its present structure in order to increase its facilities for turning out work, and proposes, in the near future, building a much larger factory, where it can have its machinery under one roof. This company is at present building 20 large dynamos, and is shipping goods to all parts of the country.

The Jerome Kidder Manufacturing Company, of 820 Broadway, N. Y., are in constant receipt of testimonials from the medical profession in regard to their well known lines of medical apparatus. Dr. E. A. Perkins, of 558 Tremont street, Boston, Mass., writes recently that a Kidder battery has given him great satisfaction for several years. "In some respects it is certainly superior to any others I have used, and I have had quite a number."

The Ansonia Electric Company, of Chicago, states that the Wirt fuse wire handled by them is standardized. The large sales this company reports of Shield brand wire, Staley transformers and Helios lamps tend to show that it is a combination that operators of plants approve of. A neat little pamphlet recently issued by the Ansonia Company, descriptive of the W. W. lightning arrester, ought to be of interest to every station superintendent.

The Southern Engineering Company, of 238 Fifth street, Louisville, Ky., electrical and mechanical engineers, are doing a prosperous business. The firm is composed of Campbell Scott, J. H. Cochran, and Harry I. Wood, the former having been local manager of the Edison company. The firm does a general electrical and mechanical engineering business, including the contracting for boilers, engines and complete steam plants, engineering and construction work, electric motors, dynamos and generators, electric light, railway and power plants, and electric wiring and construction.

The Sperry Electric Railway Company, Cleveland, O., is turning out a large amount of street railway apparatus. It is claimed that this company's apparatus was the only kind able to keep up the sub-rapid transit without blockading during the past winter. The Pittsburgh system has many steep and heavy grades, and the successful use of the Sperry company's machines has resulted in large orders from the Pittsburgh company. The company has also just received orders for 10 equipments for Youngstown, O. The Sperry company issues World's Columbian Exposition passes which are worth sending for.

The Allen Trolley Company, of 234 Carter street, Philadelphia, is placing a new trolley on the market, for which it claims several important features. The trolley requires no oil, the bearings being of Holmes' fibre graphite. The bearings are fastened in each side of the yoke, and the pin or shaft is fastened to the wheel, both revolving on the bearings in the yoke, thus making this trolley mechanically correct and avoiding any wabbling of the wheel. Another feature is the springs, which are spiral and kept inside the wheel; the springs are thus unable to get out of place and are constantly kept up to the same contact, thereby avoiding arcing and rattling.

The Ball Engine Company, Erie, Pa., has recently sold a 100 h. p. cross compound engine and other material to the Compania Mexicana del Gas y Luz Electrica; a 130 h. p. to the Inter-Mountain Electric Company, Salt Lake City, Utah, and three 100-h. p. tandem compound condensing engines to the Fond du Lac, Wis., Light and Power Railway Company. It has just shipped a 600-h. p. cross compound engine to John Good Rope Cordage Company, Ravenswood, L. I.; two 250-h. p. cross compound engines, direct connected to Siemens & Halske dynamo, for the Lumber Exchange, Minneapolis, Minn.

Walker & Kepler, of Philadelphia, Pa., have closed a contract with the Women's Christian Association, Eighteenth and Arch streets, Philadelphia, for installing an incandescent electric light plant, including dynamos, engines and fixtures. The plant will consist of two Siemens & Halske multipolar direct-coupled 40 kilowatt dynamos, running at 275 revolutions per minute; two Armington & Sims 12 × 12 automatic engines: total number of lights in the building being about 1,400. This plant will be one of the most complete in the city when finished. This firm have also closed a contract for tubing the new Girl's Normal School Building, Thirteenth and Spring Garden streets, for the interior conduit system, for 1,400 lights.

Conover & Robertson, Girard, Pa., have purchased the plant formerly used by the Keystone Manufacturing Company. The building is two stories high and 75 × 150 ft., and additions will soon be made. They have occupied this factory since May 1, and have put in all the necessary apparatus for manufacturing tempered copper segments. Messrs. J. H. Conover, of Springborough Pa., and D. P. Robertson, Glens Falls, N. Y., who are the managers of the firm, have engaged J. R. Wheeler and C. M. French, of Erie,

Pa., who have had wide experience in manufacturing tempered copper, and placed them in charge of the shops. The orders for these segments are increasing daily. The Keystone Electric Company, of Erie, uses them and expresses great satisfaction with them.

Mr. Z. Latshaw, 136 Liberty street, manager of the New York office of the National Electric Manufacturing Company, Eau Claire, Wis., reports the following recent sales: H. Eschemmeyer, New York, one 100-h. p. 500-volt generator; Watkins Electric Light and Power Company, Watkins, N. Y., one 1,200 16-c. p. alternator. Newtown Electric Light and Power Company, Newtown, L. I., one 600 16-c. p alternator; Long Branch Electric Light Company, Long Branch, N. J., one 600 16-c. p. alternator. Congers & Rockland Electric Light and Power Company, New York, one 600-16-c. p. alternator, including the complete installation of same. Mr Godfrey, president of the Long Branch Electric Light Company, before placing order with Mr. Latshaw, made thorough and searching inquiries as to the relative merits of alternators, to all of which he received the most flattering replies. This speaks well for the National Electric Manufacturing Company.

The Ashton Valve Company, 271 Franklin street, Boston, Mass., reports that after about three months of embarrassment, on account of the fire which partially destroyed its factory, it has entirely renewed its plant—a new Brown engine of the latest type together with new boilers, one of which is built for a working pressure of 300 pounds to the square inch. With these improved facilities the company is better prepared than ever to maintain its reputation for the manufacture of high grade goods. The Ashton pump safety valves and steam gauges are fully covered by patents and embody the most important and essential improvements of recent years. The valve seats are made of gun metal, or, if preferred, of nickel. The springs are made by the company of Jessop's best cast steel. The patent cam lever applied more especially to its marine valves makes it possible to lift the valve off the seat, whether there is pressure on the boiler or not. The very best workmanship and material are employed in this apparatus.

Business Notices.

Transformers rewound and repaired. Write for prices. The Hill Manufacturing Company, Salem, Va.

Oil Filters for sale cheap. Prices on application to Purity Oil Filter Manufacturing Company, 901 Water street, Pittsburgh, Pa.

Battery Cut-Out, Cheap.—Sensitive, reliable, never requires attention. Gas lighting much improved by its use. Electric Supply Company, of 105 South Warren street, Syracuse, N. Y.

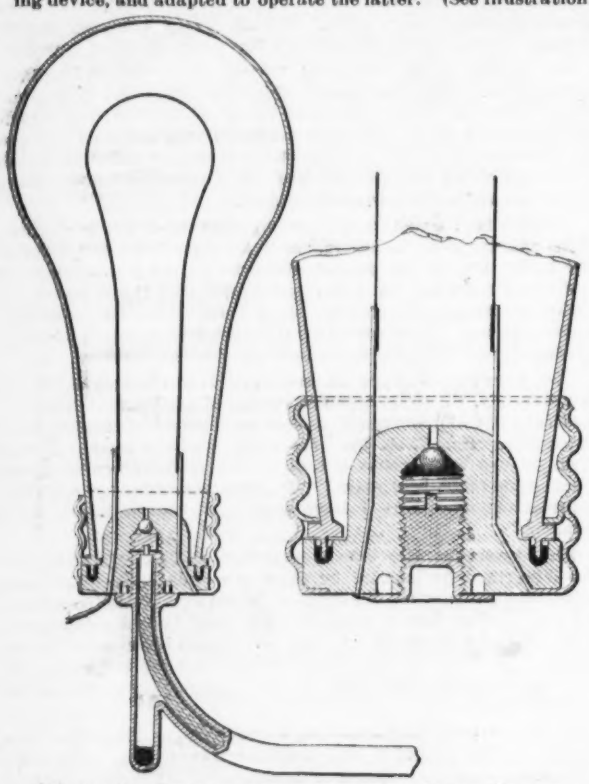
Along the Hudson River.—The charming scenery, the rare freshness of the country air, and the boundless attractions of the Hudson River towns will doubtless attract the usual multitude of summer comfort seekers during the coming season. The New York Central runs through the heart of this choice section, and its facilities for the summer traffic will be unsurpassed.—*Brooklyn Eagle.*

OUR ILLUSTRATED RECORD OF ELECTRICAL PATENTS.

UNITED STATES PATENTS ISSUED MAY 23, 1893.

[In Charge of W. A. Rosenbaum, 177 Times Bldg., N. Y.]

11,341. Incandescent Electric Lamp Socket; Isaac Goldkind, New York. Application for re-issue filed Nov. 22, 1892. A socket, an electric conductor in it, a circuit making and breaking device, an oscillating and spring-actuated lever, a cord or chain attached to the lever, and a pawl and ratchet mechanism interposed between the lever and the circuit making and breaking device, and adapted to operate the latter. (See illustration.)



No. 11,341.—INCANDESCENT ELECTRIC LAMP SOCKET.

497,771. Electric Heater; Samuel M. Cook, Boston, Mass. Application filed Jan. 17, 1893. A heater or electrically heated article provided with a coiled flange, in combination with a wire which is wound on the flange and reversed in the winding to prevent magnetism, the wire forming part of an electric circuit.

497,790. Electric Broiler; Sam. B. Jenkins, Boston, Mass. Application filed Oct. 14, 1892. A frame provided with tubular transverse bars, having their ends set into the sides of the frame and expanded, magnetizable rods arranged in the tubular bars and an insulated wire forming part of an electric circuit, which is wound on the rods. (See illustration.)

497,791. Electric Radiator; Sam. B. Jenkins, Boston, Mass. Application filed Nov. 25, 1892. The combination of a plate having tongues stamped out of it so as to project laterally with an insulated wire wound from tongue to tongue in serpentine lines and forming part of an electric circuit.

497,792. Electric Flat Iron Heater; Sam. B. Jenkins, Boston, Mass. Application filed Dec. 5, 1892. In combination with two plates and means for clamping them together, interposed pieces of resisting material, bars or plates connecting them in a continuous chain of resistance, and interposed between the two plates and the pieces and electrical connections making circuit through the chain.

No. 497,790.—ELECTRIC BROILER.

497,793. Electric Soldering Iron; Sam. B. Jenkins, Boston, Mass. Application filed Dec. 5, 1892. A soldering iron having within its body a pile of discs or plates of resisting but conducting material, in combination with electric connections making circuit through the pile and the point of the iron.

497,794. Electric Heater for Flat Irons or Other Articles; Sam. B. Jenkins, Boston, Mass. Application filed Dec. 5, 1892. A pair of bars of graphite and electrical circuit connections in combination with an end coupling consisting of a winding of wire and an interposed metallic block.

497,795. Electric Heater; Sam. B. Jenkins, Boston, Mass. Application filed Dec. 8, 1892. The combination of a series of non-metallic bars with a series of metallic bars or pieces making connection between the ends of the former bars, clamping devices for holding the two kinds of bars together to form a continuous electrical resistance and an insulating plate to which the bars are fastened by the clamping devices.

497,800. Thermostat; Emil C. C. Krogh, Monmouth, Ill. Application filed Jan. 11, 1893. In combination with a temperature actuating contact of a thermostat, the longitudinally movable contact rod, held normally from the other, the adjusting cam, the longitudinally movable shaft carrying said cam, the toothed wheel to hold said shaft from rotating, and the spring pressed collar to engage said pawl.

497,808. Railroad Rail and Process of Uniting Same; Arthur J. Moxham, Johnstown, Pa. Application filed April 27, 1892. The method of electrically welding two pieces of metal together, which consists in first welding the central portion of the adjacent ends of said pieces together by passing an electric current through the ends of said pieces on opposite sides of the centre into their central portion and then welding together the remaining portions of the adjacent ends.

497,822. Electro-Therapeutic Appliance; Henry C. Royer, Los Angeles, Cal. Application filed Oct. 3, 1892. A shoe sole provided with an interior plate adapted for contact with the foot of the wearer and an electrical conductor arranged to engage such plate and adapted to form therewith an electrical connection between the earth and the wearer of the shoe.

497,832. Electric Mining Machine; Elmer A. Sperry, Chicago Ill. Application filed Oct. 8, 1888. A moving manually directible bi-wheeled excavating machine, consisting in part of a power motor having the axis of the shaft of the motor parallel with the axis of its supporting wheels, combined with a flexible connection to the source of power supply.

497,836. Safety Block System for Railway Signaling; William R. Sykes, Jr., and John P. O'Donnell, London, England. Application filed Oct. 1, 1892. The combination of a signal operating rod having a plate at its lower end, and the lever pivoted to the said plate and normally retained in a vertical position by gravity of the lower part of the said rod provided with a beveled end adapted to turn the lever on its pivot when raised, and the electrically controlled pivoted lever provided with a hooked end adapted to be moved in engagement with the upper end of the lever when the signal is to be lowered, thereby locking the said lever in its vertical position.

497,838. Safety Appliance for Systems of Electric Distribution; Elihu Thomson, Lynn, Mass. Application filed Jan. 29, 1890. The combination with a ground branch containing electrodes separated by a narrow vacuous space, of a condenser in a branch around same. (See illustration.)

497,841. Electrical Fuse Link; Marion C. Walls, Plymouth, Ind. Application filed March 2, 1893. An electrical fuse link containing in combination two copper wire staples flattened at their extremities and a fusible wire joining and fastened to said staples by winding it upon and with them.

497,849. Wall Socket for Incandescent Lamps; Herbert C. Wirt, Boston, Mass. Application filed March 7, 1892. A wall socket for incandescent lamps consisting of an insulating support having front and rear chambers, and having the wall of the rear chamber slotted and contacts extending out through such slots and provided at their outer ends with external wire engaging clips, and having their inner ends extending into the lamp or front chamber and supporting the lamp.

497,852. Insulation for Underground Wires; Parvin Wright, Denver, Colo. Application filed Jan. 27, 1890. An electrical conductor surrounded by a series of longitudinally divided insulating washers, which when in position rest against the inner wall of a surrounding or inclosing tube whereby the conductor is maintained in the axial centre of the tube.

497,869. Electric Accumulator; Paul J. R. Dujardin, Paris, France. Application filed March 15, 1892. The process of forming accumulator plates, consisting in decomposing a proportion of alkaline nitrate by an electric current in an acidulated bath, whereby the reactions indicated are caused, and producing on the plates an adhering layer of peroxide of lead.

497,887. Armature for Electric Motors or Generators; James F. McLaughlin, Philadelphia, Pa. Application filed Dec. 17, 1891. An armature for electric motors and generators composed of a circular series of iron sections each formed with a longitudinal channel, and armature coils housed in said channels.

497,888. Electric Motors or Generators; Jas. F. McLaughlin, Philadelphia, Pa. Application filed July 27, 1892. In an electric motor or generator, an armature having a core composed of ring-shaped laminæ, in combination with interlocking supporting spiders.

497,899. Electrode Shield for Arc Lamps; Chas. E. Scribner, Chicago, Ill. Application filed Nov. 3, 1890. The combination with carbon electrodes of an electric arc lamp of a cap held suspended from the burning substance of the upper end of the lower carbon, and a cone-shaped shield loosely surrounding the lower portion of the upper carbon, this shield being sustained by the cap and insulated therefrom.

497,923. Thermostatic Instruments; Morris Martin, Malden, Mass. Application filed Aug. 9, 1892. The combination with an insulating body provided with hollow circuit terminals, of an expansible active member and fusible connections joining the active member to the body and electrically connecting it to the members with the hollow terminals.

497,942. District Telegraph Return Signal Key; J. M Bell, Tacoma, Wash. Application filed Oct. 24, 1892. In a keyboard having four outer contact pieces arranged on the circumference of a circle and two inner contact plates on a line with two outer plates, of an insulated pivot in the centre of the circle, a lever made of insulating material on the pivot, a metal strip on top of the lever and bent over its ends, and a bridge piece with turned down ends on the bottom of the lever.

497,955. Temporary Circuit Connections for Incandescent Electric Lamps; Gustav A. Frei, Springfield, Mass. Application filed Dec. 19, 1892. A temporary connector for electric lamps consisting of a disc or body which has at one side metallic contact pieces insulated the one from the other and adapted to be placed in contact with the terminals of the lamp and contact pieces on the other side of the body, which are in metallic connection with the first named contact pieces, and a spring clip detachably connected to the second set of contact pieces, and current wires connected thereto.

497,956. Incandescent Lamp; Gustav A. Frei, Springfield, Mass. Application filed Dec. 19, 1892. This lamp has two contact pieces, leading-in wires and filament, and a spring connected to one of the contact pieces and extended to lie across the other and having a cavity or recess therein and a substance which is easily fusible and a high resistance bearing in the cavity of the spring and also against one of the contact pieces.

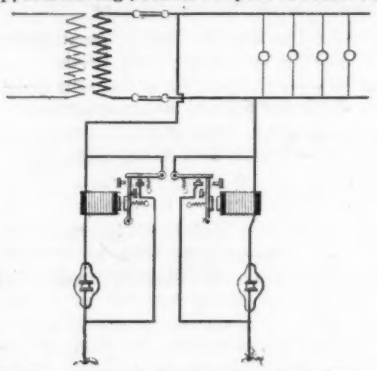
497,957. Incandescent Electric Lamp; Gustav A. Frei, Springfield, Mass. Application filed Feb. 7, 1893. The combination with the filament of an incandescing electric lamp, of a filament anchor attached by one end to the lamp mount and extending therefrom toward the opposite end of the lamp and having a loop on its free end to receive one arm of the filament.

497,963. Combined Nut Lock and Electrical Connection for Railroad Rails; Albert L. Johnson, Cleveland, O. Application filed April 27, 1893. The combination with a rail joint secured to the rails by bolts and nuts, of a nut locking device adapted to secure these nuts and to transmit electricity, the ends of the nut locking device being connected to the rails so as to form electrical connections.

498,021. Electric Current Time Meter; Henry H. Pattee, Monmouth, Ill. Application filed Sept. 6, 1890. The combination with an electromagnet, its armature, a clock movement, and time register in gear with the clock movement, a rod connected with the armature at one end, an elbow lever to which the other end of the rod is pivoted, a sliding bar which is adapted to be operated by the elbow lever, a yielding brakeshoe carried by the sliding bar which slides into and out of frictional contact with the balance wheel of the clock movement.

498,022. Electric Current Time Meter; Henry W. Pattee, Monmouth, Ill. Application filed Sept. 6, 1890. The combination with an electromagnet, its armature, clock movement and time registering mechanism, of a trip mechanism operated by the movements of the armature, and consisting of a rod which is connected at one end with the armature, the other being connected with one arm on an elbow lever, another arm of this lever being adapted to engage with or operate a clutch to throw the clock movement into gear with the time register.

498,046. Electric Railway Trolley; Edward H. Allen, Cramer Hill, N. J. Application filed Nov 16, 1892. The combination with a trolley wheel, spindles thereon, pockets in each side of the wheel, springs in the pockets, bearings for the spindles and bearing supports having pockets adapted to receive the bearings.



No. 497,838.—SAFETY APPLIANCE FOR SYSTEMS OF ELECTRIC DISTRIBUTION.

498,078. Method of Manufacturing Electric Heaters; Henry G. O'Neill, Boston, Mass. Application filed Aug. 20, 1892. This invention consists in molding a carbonizable filament inside a heater body composed of plastic material, and in subsequently heating the body and filament to bake the former and carbonize the latter.

498,135. Conduit Electric Railway; George F. Moffett, Portland, Ore. Application filed Oct. 7, 1892. In an electric railway, the conduit comprizing a suitable wall, and inclosing frames or yokes arranged at intervals outside the wall.

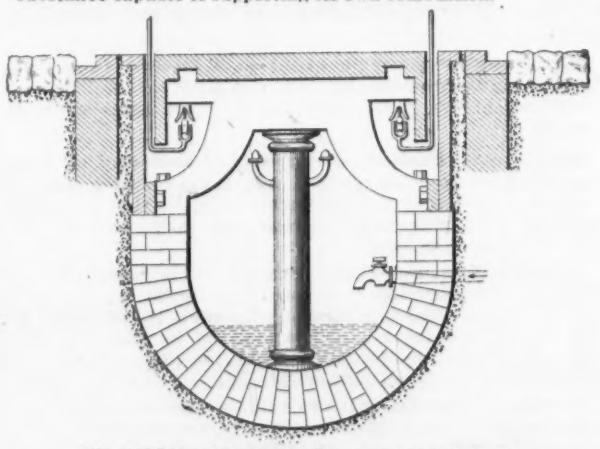
498,141. Electrode for Arc Lamps; Albert C. Seibold, Mt. Vernon, N. Y. Application filed Feb. 28, 1893. An electrode or carbon provided with two coatings of different metals and an intermediate coating of graphite.

498,153. Thermal Circuit Closer and Indicator; Jay L. Bradley, St. Louis, Mo. Application filed Dec. 5, 1892. In an electric indicator the combination of contact points, a movable object having contact points, and a fusible plug and stop.

498,160. Electric Steering Gear; Frank L. Dyer and Leonard H. Dyer, Washington, D. C. Application filed April 18, 1891. The combination of an electric motor having its moving parts connected to and operating the valves or equivalents, a prime mover; and an independent commutator connected with the coils of the armature of the electric motor.

498,169. Electric Railway Conduit; Arthur H. Hieatzman, Baltimore, Md. Application filed July 28, 1891. In combination, yokes resting at each end upon suitable foundations, the covering plates resting on the yokes, the aprons at the outer edges of the covering plates, the side plates which the aprons form, the slot wall, and the aprons projecting into the conduits to separate them from the slots. (See illustration.)

498,183. Torpedo; Samuel E. Mower and G. E. Haight, New Haven, Conn. Application filed July 5, 1892. This invention consists of a flask containing a power fluid, combined with a heating chamber to raise the temperature of the power fluid when passed therethrough, and a heater containing a heating substance capable of supporting its own combustion.



No. 498,169.—ELECTRIC RAILWAY CONDUIT.

498,189. Electric Railway Conduit; Jos. L. Reynolds, Winterset, Ia. Application filed July 23, 1892. This consists of a shoe in combination with an electric car, depending therefrom and having on its lower edge two wedge-shaped projections oppositely disposed and extended longitudinally of a car, a trolley support extended through the shoe and insulated therefrom and adapted to move vertically therein, means for elevating the trolley support and means for elevating the lower end of the shoe. (See illustration.)

Copies of the specifications and drawings complete of any patent mentioned in this record—or of any other patent issued since 1886 can be had for 25 cents. Give date and number of patent desired and address The W. J. Johnston Co., Ltd., Times Building, N. Y.

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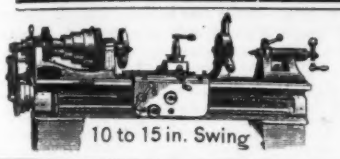

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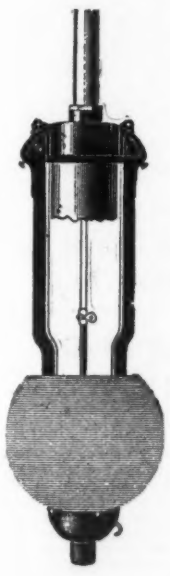

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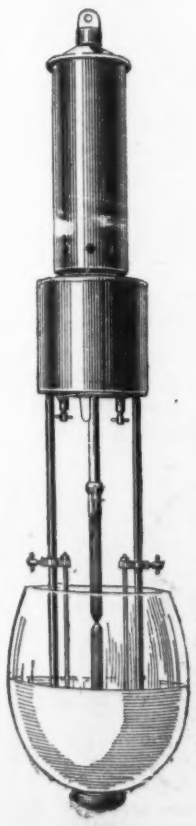

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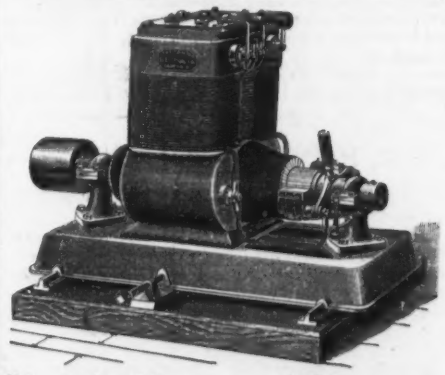

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One	18 "	6	"	" " "	"
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One	9½ "	30	"	Brush " with	"
One	9½ "	25	"	Ball " "	"
Two	18 "	20	"	U. S. " "	"
One	18 "	90	"	Jenney " "	"
Two	18 "	16	"	" " "	"
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Two hundred	18 "	double Van Depoel	"	
Forty-five	18 "	single "	"	
Fifty-four	9½ "	" Excelsior	"	
Five	9½ "	double "	"	
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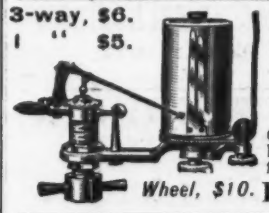

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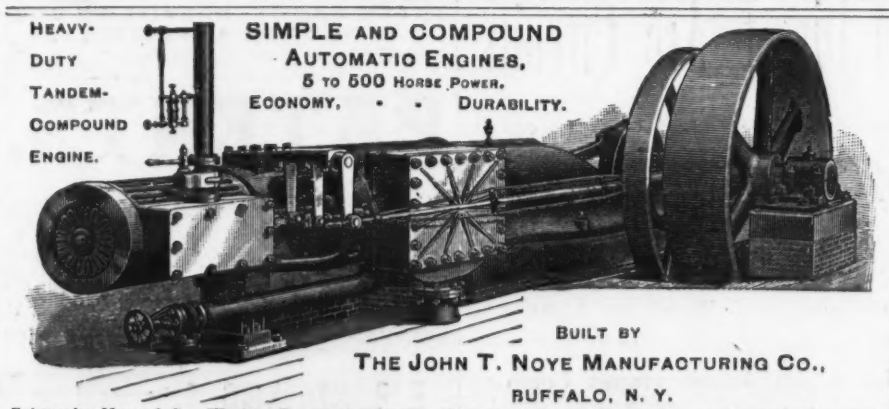

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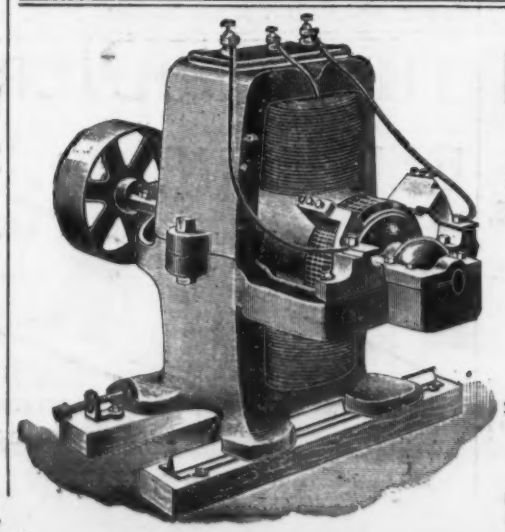

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Notice is hereby given that in pursuance of an order of the Circuit Court of Milwaukee County, Wisconsin, I will, on the 30th day of June, A. D. 1893, at eleven o'clock in the forenoon of said day, at the south door of the court house in the city and county of Milwaukee, Wisconsin, offer for sale and sell at public auction, as an entirety, the street railway of the Milwaukee Electric Railway Company, in said city of Milwaukee, with all the franchises and rights and privileges of said railway company for the operation and maintenance of the same, and all the property of said corporation used in or in connection with, or essential to the exercise of its said franchises.

Said railway property and franchises consist of about 6½ miles of double track, being about 13 miles of single track, in said city of Milwaukee, with all the poles, wires, cables, trucks, ties, stringers, fixtures and appliances composing or used in connection with said tracks or said railway, with franchises, privileges and rights derived from ordinances of the common council of the city of Milwaukee to maintain and operate said road; also sundry parcels of real estate in said city, with car barns and power-house thereon; also the engines, boilers, machinery and rolling stock and supplies of said road.

The terms of such sale are cash.

The said street railway will be sold free of all liens and encumbrances except judgments of foreclosure and sale aggregating $21,193.56, with interest from the 22d day of November, 1892, at 7%, on $1,259.60 thereof, and at 6% per annum on the remainder, said judgments of foreclosure covering the said specific parcels of real estate.

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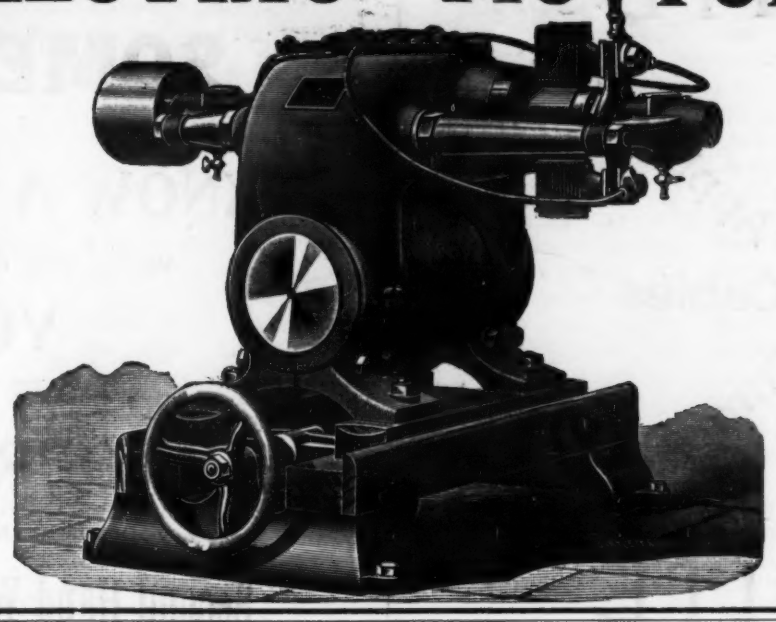

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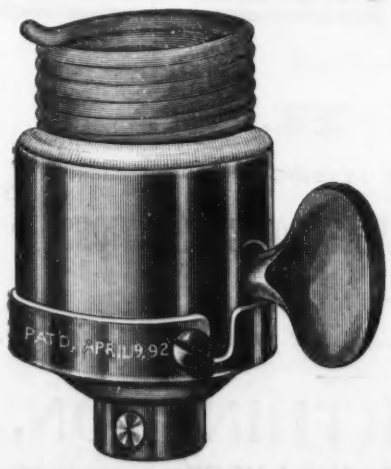

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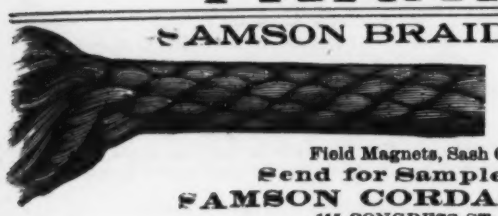

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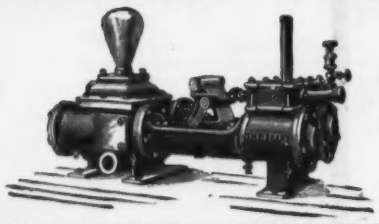

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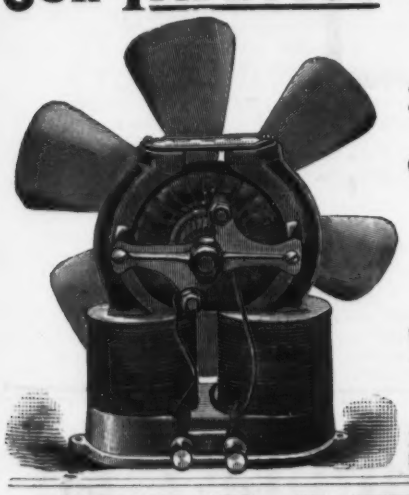

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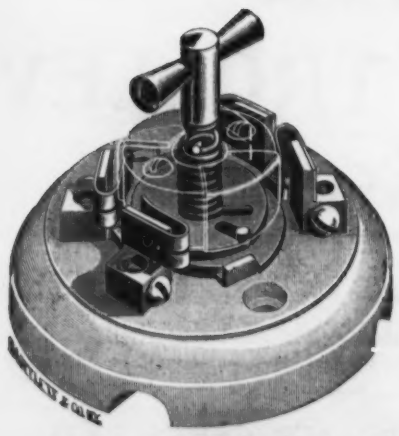

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